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SURGICAL MEMOIRS

OF THE

WAR OF THE REBELLION.

COLLECTED AND PUBLISHED

BY THE

UNITED STATES SANITARY COMMISSION.

I.

ANALYSIS OF FOUR HUNDRED AND THIRTY-NINE RECORDED AMPUTATIONS IN THE CONTIGUITY OF THE LOWER EXTREMITY.

BY

STEPHEN SMITH, M. D.

II.

INVESTIGATIONS UPON THE NATURE, CAUSES, AND TREATMENT OF HOSPITAL GANGRENE, AS IT PREVAILED IN THE CONFEDERATE ARMIES, 1861–1865.

BY

JOSEPH JONES, M. D.

PROFESSOR OF CHEMISTRY IN THE MEDICAL DEPARTMENTS OF THE UNIVERSITY OF LOUISIANA, NEW ORLEANS; FORMERLY SURGEON IN THE PROVISIONAL ARMY OF THE CONFEDERATE STATES.

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EXPLANATION OF THE PLATES.

PLATE I.

Gangrenous Ulcer of Finger of Confederate Soldier. Case VII. W. J. Black, pp. 248–250.

At the time of the appearance of the gangrene, the patient was acting as a nurse in the Gangrene Hospital, at Vineville, near Macon, Georgia. A small blister appeared upon the third finger of the right hand, which gave much pain, assumed a dark gray and greenish color, and was surrounded by a purplish and blue border in the skin. Concentrated nitric acid did not arrest the progress of the gangrene; and this failure of the local treatment appeared to be due to the gradual poisoning of the system during the continued residence of this nurse in the infected atmosphere of the gangrene hospital.

The drawing was executed on the thirteenth day after the appearance of the gangrene.

The gangrene spread progressively along the borders, under the blue discolored skin. Notwithstanding the comparatively small surface involved, the constitutional symptoms in this case were well marked.

PLATE II.

General Appearance and Extent of Gangrenous Wound of Thigh of Confederate Soldier. Case VIII. Thomas Paine, pp. 250–256.

This patient was wounded on the 17th of August, 1864, at Atlanta, Georgia. A fragment of lead weighing about one pound projected from a rifle shell, struck the middle of the left thigh, upon the external surface, and lacerated the parts, but did not fracture the bone. Gangrene attacked the wound on the tenth day. The drawing was executed on the thirty-first day after the appearance of the gangrene, and at this time the wound in the thigh was about eight inches in diameter, nearly circular, deeply and irregularly excavated, and coated with dark greenish gray and bluish and brown matter. No healthy pus was discernible; but in its stead the wound discharged a fœtid sanious fluid. The large muscles of the thigh were exposed, and could frequently be observed quivering, especially after the application of nitric acid, which caused intense pain. Patient restless and nervous, with trembling hands and quivering distressed eyes.

EXPLANATION OF THE PLATES.

PLATE III.

General Appearance of Wound of Thigh of Thomas Paine, after the Disappearance of Hospital Gangrene. Case VIII. pp. 250–256.

This drawing was executed twenty days after Plate No. 2. At this time the wound was improving, presenting a bright red granulating surface, and discharging healthy pus. By a comparison with the drawing of the wound during the state of gangrene (Plate No. 2), it will be seen that the parts surrounding the wound have greatly diminished in size, and that with the disappearance of the gangrene, and the improvement of the wound, the swelling and effusion have also disappeared.

PLATE IV.

Appearance of Internal Surface of Portion of Femoral Vein in Case of Pyæmia. Case XLVI.[1] *Ira Parker, Confederate Soldier, pp.* 415–439.

The femoral vein was distended with thick yellow pus. Many of the venous branches were in like manner filled with yellow pus. The popliteal vein and its branches, the anterior and posterior tibial veins, were traced to the disorganized tissues, and were in like manner distended with thick, cream-like yellow pus. At various intervals, but chiefly at the junction of the large vessels with the main trunk, and also in the region of the semi-lunar valves, clots of blood were found mingled with the pus, and firmly attached to the sides of the veins. At such points the walls of the veins appeared to be discolored by the coloring matter of the blood, and to be more softened than in those positions where no clots had been formed. The veins were traced directly to the disorganized tissues of the calf and leg; and in the diseased, broken-down diffluent tissues and pus, the walls of the veins were rotten, and gave way upon the slightest touch. The femoral vein, near where it is continuous with the popliteal, and where several branches were received, and where there were semi-lunar valves, was much distended, and presented upon its exterior a dark blue gangrenous appearance. This portion of the femoral vein is represented in the Plate by 1, 2. The remnants of the coagula at the mouths of several vessels, and also attached to the semi-lunar valves, were here visible. The internal surface of this portion of the vein was covered with a tenacious fibrinous exudation, of a greenish yellow and bluish gray color, as represented in the Plate (1, 2), which adhered with tenacity. When this was scraped off, the walls of the vein presented a grayish-blue and black color, and evidently appeared to be gangrenous. The odor of the pus as well as of this portion of the vein was similar to that of tissues affected with hospital gangrene.

[1] The Plate is incorrectly numbered Case XLIV.

EXPLANATION OF THE PLATES.

PLATE V.

Microscopical Appearance of Dark Gray, Green and Black Portions of the Exudation upon Surface of Femoral Vein in Case of Pyæmia. Case XLVI. Ira Parker, p. 425.

Exhibiting granular masses, with dark masses of the altered hæmatin of the blood, together with pus globules and masses of fibrous tissue, broken capillaries and fragments of muscular tissue: many of the particles of coloring matter presenting a smooth angular fracture, as if they were crystallized.

ANALYSIS

OF

FOUR HUNDRED AND THIRTY-NINE RECOVERED AMPUTATIONS IN THE CONTINUITY OF THE LOWER EXTREMITY.

BY

STEPHEN SMITH, M. D.

ANALYSIS OF RECOVERED AMPUTATIONS.

GENERAL REMARKS.

AMPUTATIONS have been the subject of more discussion than any other branch of military surgery. At one period we find them regarded as the true method of treatment of every considerable wound of the extremities, and at another period they have been rejected altogether, and the injured limbs have been left to the rude appliances of the time. Their value has generally been estimated by the mortality that has followed, and this has varied with nearly every campaign. Hence have arisen those remarkable fluctuations of opinion which are recorded in the earlier history of military surgery. It is but a century since that Bilguer, the Surgeon-General of the Prussian army, alarmed at the great fatality of amputations in the wars of that age, prohibited them altogether, preferring to leave the wounded to the then almost unaided efforts of nature. The results of this expectant plan of treatment, or non-operative interference, as reported by him, were so favorable when compared with amputations, that professional opinion for a long period favored an adoption of the expectant method.

Former opinions as to the value of amputations in military surgery.

The fallacy of the reasoning of Bilguer, and of those who advocated his practice, is now very apparent. They made no distinction as to the time at which the amputation was performed after the receipt of the injury. Nor were the circumstances relating to the patient and his subsequent surroundings duly considered. When at a later period the causes of the fatality of amputations began to be more thoroughly understood, and the time of the operation more judiciously selected, the mortality was much reduced, and the operation again became the popular method of treating severe wounds of the extremity.

Fallacy of the reasoning.

But the great advance in practical surgery within the last quarter of a century, has again modified the opinions of surgeons as to the necessity and value of amputations for gunshot wounds. Compound fractures are now treated with a

Effect of conservative measures.

success formerly unknown, and many limbs are saved that a century ago were incontinently sacrificed. The remarkable success which has attended exsections for gunshot injuries of bone, both in saving life and in securing a useful limb, has rescued another large class of cases formerly condemned to amputation. Every campaign has enlarged the experience of military surgeons in the application of conservative measures, and thereby limited more and more the field of amputations. The Crimean and Schleswig-Holstein wars gave a powerful impulse to conservatism in military surgery, the former by its frightful mortality after amputations, and the latter by the great successes which attended conservative measures, especially exsections.

Absolute necessity of amputations in military surgery.

But notwithstanding these great improvements in the treatment of gunshot wounds of the extremities, whereby many lives and limbs are saved that were formerly sacrificed, it cannot be denied that amputations must still occupy an important place in modern military surgery. The liability of the extremities to wounds and injuries is rather increased than diminished by the improved methods of warfare, while their severity is greatly enhanced by the destructive nature of the missiles employed. These facts may be illustrated by the records of the late war; of 87,822 wounds and injuries classified by the Surgeon-General from official returns, 55,245, or nearly two thirds, were located in the extremities, and from the same source it appears that of 17,125 operations of various kinds, 13,397, or about three fourths, were amputations. While it may be true that many of these amputations might have been avoided by the judicious employment of conservative means, it is nevertheless equally certain that in a vast majority of cases the wounds were amenable to no other form of treatment than amputation. We can scarcely believe it possible that a campaign will ever again be inaugurated with an official order from the chief medical officer prohibiting *all* amputations.

Position of the various questions relating to amputations at commencement of the war.

The position of the various questions relating to amputations at the commencement of the late war can be stated only in general terms. Many questions which had hitherto divided surgeons were now definitely settled. There was no longer any doubt as to the success of primary when compared with secondary amputations. A broad distinction was very properly drawn between amputations in the upper and lower extremities, based upon the difference in their functions. Every possible effort was advised to save the upper limb by con-

servative measures. Exsection was well adapted to preserve the functions of the upper extremity, and was strongly recommended at any of its articulations involved in a gunshot injury in preference to amputation. Lesions of the shafts of the long bones were also treated conservatively to the utmost practicable limit. In the lower extremity far less importance was attached to conservative measures; exsection here became a formidable operation, and not only imminently endangered life, but at best its results were doubtful as regarded the serviceableness of the resulting limb. Gunshot fractures of the long bones, especially when severe, were generally condemned to amputation unless occurring under the most favorable circumstances for treatment.

The propriety of amputation at the articulations of the upper extremity was well established; but the same operation in the lower extremity was regarded with little favor. Amputation at the ankle-joint had attracted some attention, but in general surgeons preferred amputation through the leg, and practiced the old routine.

The point of amputation was still determined by the old rule of operating as far from the trunk as possible, or certain points of election were selected, originally fixed by circumstances or conditions long since become obsolete. The methods of operation were altogether unsettled, the preference being generally given to the circular and the flap.

Amputations formerly regarded as mutilations.

Formerly amputations were regarded as veritable mutilations. They were the dernier ressort, the only alternative of which was death. The operation was repugnant alike to surgeon and patient, as by it the latter seemed reduced to an almost helpless condition. No appliance could compensate for the loss of either an upper or lower extremity. For a hand nothing had yet been invented which even preserved the form, while the clumsy peg-leg was a substitute only in length. But in our time limb-making has been carried to such a state of perfection that both in form and function they so completely resemble the natural extremity that those who wear them pass unobserved and unrecognized in walks of business and of pleasure.

Compensative appliances.

The conservatism of artificial appliances has, therefore, become a most important department of both civil and military surgery. Amputations are no longer to be regarded as mutilations, especially in military surgery, as the government, in its munificent care of its soldiers, gratuitously furnishes every form of artificial substitutes for lost parts. In this respect amputations have become eminently a conservative measure. The surgeon has

not only to consider the probabilities of saving life by his operation, but also the possibilities of giving his patient a better limb with an artificial appliance than he would have if the injured limb were retained.

Direction in which we are to look for improvements during the war.

From this statement it is apparent that there was ample room for improvement in this field of operative surgery, and we readily perceive in what direction we are to look for the results of the experience in the late war. In the first place we should expect to have all the circumstances and conditions which determine a resort to conservative measures, rather than to amputation, more accurately defined. When amputation becomes the alternative, the period after the injury best adapted to secure successful results, as regards the mortality, would be thoroughly investigated and definitely fixed. The old landmarks which defined the boundary between primary and secondary amputations could scarcely fail of being removed, and others more discriminating established. Again, the much disputed question in regard to the propriety of amputation at the articulations would now find a practical solution. Not only should we expect to have the general question as to the comparative dangers of these operations settled, but equally should we have a fixed value placed upon amputation at each individual articulation. Another and not less important subject is the determination of the influence which the point of amputation and the methods of operation has upon the usefulness of the stump in the final adjustment of artificial appliances. This is a new question and of the greatest importance to the future happiness and comfort of the patient.

How far the reasonable anticipations of the profession of the final settlement of the various questions relating to amputations have been realized by the vast experience of the late war, we are not in a position to decide. These final conclusions will be developed only when the accumulated facts of the entire surgical service are reduced and systematized by the Central Official Bureau.

Scope of this article.

The following paper is a contribution to our knowledge of the results of amputation in the lower extremity. It is based upon the careful study of the stumps of patients when prepared for the application of artificial limbs. Many of them came under our own observation at the U. S. General Hospital, at Central Park, New York. This hospital was, for upwards of two years, the rendezvous of soldiers who had lost their limbs by amputation, and, while inmates, large numbers were supplied with artificial limbs by Dr. E. D. Hudson, of New York, who held a

government commission for the manufacture and adjustment of appliances to compensate for losses, deformities, etc., resulting from the service. In the practice of mechanical surgery, Dr. Hudson combines the learning and experience of an educated practical surgeon, with a high degree of mechanical skill and ingenuity. In the adjustment of artificial limbs his observations have extended beyond the mere mechanics or art of his profession, and he has made careful studies of subjects relating to stumps, of great practical interest to surgeons.

The records from which the following tables are compiled, were made by Dr. Hudson upon blanks at the bedside of each patient preparatory to the adjustment of each limb. The measurements were all made with great care, and with that accuracy which only a mechanic after long experience can attain to, and they may be relied upon as nearly absolutely correct.

While the view which we take of amputations must necessarily be quite limited, it nevertheless involves some points which are novel and of very great importance. Never before have we had an opportunity of studying on a large scale the final results of amputation. These tables enable us to estimate with great precision the absolute and relative value of the various methods of operation, and of the stumps in different parts of the limb, and of the serviceableness of artificial limbs under every varying condition of stump.

TABLE OF ONE HUNDRED AND FIFTY-EIGHT CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
T. D.	7th Conn.	Sailor	L.	Middle third	Anterior flap	At Post Hospital	One hour	Fragment of shell
R. S.	9th U. S. C. T.	Farmer	R.	Lower third	Lateral skin flaps and circular	On the field	Four hours	Fragment of shell
C. H. S.	1st N. Y. A.	Farmer	R.	Middle third	Circular	On the field	Three hours	Fragment of shell
J. C.	11th Conn.	Farmer	L.	Lower third	Lateral flaps	On the field	Immediately	Solid shot
G. B. F.	14th N. Y. Vols.	Teamster	R.	Lower third	Circular	On the field	One day	Minie-ball
E. J.	1st U. S. A.	Farmer	L.	Lower third	Ant. post. flaps	On the field	One hour	Fragment of shell
S. C. T.	159th N. Y. Vols.	Clerk	L.	Lower third	Ant. post. flap	On the field	Twenty-fo'r hours	Rifle-ball
B. B.	160th N. Y. Vols.	Farmer	L.	Middle third	Circular	On the field	Six hours	Fragment of shell
W. C.	14th U. S. Infantry	Farmer	L.	Lower third	Circular	On the field	Six hours	Minie-ball
G. S.	1st U. S. Cavalry	Laborer	L.	Lower third	Ant. post. flap	On the field	One hour	Minie-ball
R. A.	1st U. S. S. Shooters	Military	R.	Lower third	Ant. post. flap	On the field	Five hours	Musket-ball
A. H.	6th Harris Cavalry	Carpenter	L.	Lower third	Circular	On the field	Nine hours	Minie-ball
J. McG.	4th U. S. Cavalry	Laborer	L.	Middle third	Ant. post. flaps	State Hospital, Columbus, Ga.	Two weeks	Piece of shell
H. E. P.	7th Verm't Vols.	Machinist	R.	Lower third	Ant. post. flap	On the field	Thirty h'rs	Solid shot
T. P.	20th Ind.	Cooper	R.	Lower third	Ant. post. flap	Rebel camp	Twenty-fo'r hours	Musket-ball
J. F. E.	U. S. S. C.	Clerk	L.	Middle third	Ant. post. flaps	On the field	Twenty h'rs	Rifle-ball
C. J. O'B.	24th N. Y. Vols.	Tinman	R.	Middle third	Circular	Field hospital	Two hours	Rifle-ball
A. G. I.	9th N. Y. M.	None	R.	Middle third	Circular	In Frederick Hospital, Md.	—	Musket-ball
T. P.	5th U. S. A.	Laborer	R.	Middle third	Ant. post. flap	On the field	Immediately	Solid shot
N. A. U.	48th N. Y. Vols.	Military	R.	Lower third	Bilateral flaps	On the field	One and a half hour	Minie-ball
R. B.	U. S. Navy	Landsm'n	L.	Middle third	Ant. post. flap	U. S. gunboat	Twenty-fo'r hours	—
J. D.	69th N. Y. Vols.	Carpenter	R.	Middle third	Ant. post. flap	Frederick City Hosp'l	Thirty-seven days	Minie-ball
G. D.	51st N. Y.	Laborer	L.	Lower third	Ant. post. flap	Field hosp'l, St. Joseph's, Governor's Island	Twenty-fo'r hours	Shell
A. T.	9th N. Y.	Joiner	R.	Upper third	Ant. post. flap	Falmouth	Twenty-fo'r hours	Grape-shot
T. W. D.	82d N. Y.	Clerk	L.	Upper third	Ant. post. flap	On the field	Three days	Shell
H. D.	28th Mass.	Tailor	R.	Lower third	Post flap	On the field, 2d Staunton Hospital	Eight days	Minie-ball 2d time, insuffic'nt flap

OF RECOVERED AMPUTATION OF THIGH.

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Compound comminuted fracture of knee-joint	Fort Wagner, S. C.	Oct. 8, 1863	6 mos.	8 mos.	7½ inches	None	2 inches	Stump healed, very well formed, efficient.
Destruction of foot and ankle-joint	Chapin's Bluff or Farm, Va.	Sept. 29, 1864	4 mos.	9 mos.	11 inches	¼ inch	2 inches	Very good, compact, well formed, healed by the first intention.
Comp'nd comminut. fract. of lower third of thigh	Chancellorsville	May 1, 1863	6 mos.	6 mos.	6 inches	⅜ inch	1 inch	Stump not healed, end of femur not well covered.
Comp'nd comminuted fracture of knee-joint and condyles of fem'r	Antietam, Md.	Sept. 17, 1862	9 mos.	10 mos.	10 inches	1¾ inches	None	Good, sm'th stump, well cicatrized.
Comp'd fract. lower third of thigh	—	June 1, 1864	13 mos.	14 mos.	7 inches	1 inch	2 inches	Well healed.
Destructi'n of knee and leg	Port Hudson, La.	May 28, 1863	9 mos.	10 mos.	9¼ inches	1 inch	3 inches	Stump well covered by anterior flap, posterior flap redundant, flaccid.
Comp'd com. fract. of middle leg, knee uninjured	Port Hudson, La.	May 2, 1863	7 mos.	15 mos.	12¾ inch.	1 inch	4 inches	Stump diseased, eczema.
Nearly dissevering limb at knee-j'int	Port Hudson, La.	May 27, 1863	6 mos.	7 mos.	6½ inches	None	½ inch	Stump muscles retracted, femur protrudes, not entirely healed, ordered bandaging from above downward.
Comp'd com. fracture of knee-j'int	Petersburg, Va.	Aug. 18, 1864	9 mos.	11 mos.	10 inches	2½ inches	2 inches	Considerably atrophied, very good.
Comp'd com. fracture of knee-j'int	Deep Bottom, Va.	July 28, 1864	4 mos.	6 mos.	9¾ inches	None	None	Healed, very good.
Comp'd com. fract. low. th'd of thigh	Deep Bottom, Va.	Aug. 15, 1864	5 mos.	—	9½ inches	¼ inch	2 inches	Healed, very good.
Comp'd. com. fracture of knee-j'int	Bull Run, Va.	Aug. 29, 1862	13 mos.	1 year & 11 mos.	10½ inch.	3 inches	3 inches	Stump healed.
Muscular tis. of leg entirely denuded fr. ankle to knee	Columbus, Ga.	April 16, 1865	8 mos.	—	7½ inches	1 inch	2½ inches	Injured by necrosis, bone removed, not entirely healed.
Comp'd com. fract. low. th'd of fem'r	Spanish Fort, Md.	M'ch 29,	8 mos.	9 mos.	11 inches	2 inches	2 inches	Excellent.
Comp'd fracture of knee-joint. . .	Fair Oaks, Va.	June 25, 1862	6 mos.	9 mos.	10 inches	3 inches	3 inches	—
Wound of knee .	Fair Oaks, Va.	June, 1862	6 mos.	—	9½ inches	2 inches	⅜ inches	Not yet sound, ulcer and fetid discharges.
Comp'd fracture of knee-joint. . .	Antietam, Md.	Sept. 17, 1862	3 mos. & 1 year	—	7 inches	1½ inches	None	Diseased, herpes, enlarged.
Wound of knee-joint	Antietam, Md.	Sept. 17, 1862	3 mos.	—	6½ inches	½ inch	None	Stump unsound, retraction muscles, bone exposed, necrosis, exfoliations in process.
Destruct. of knee-joint	Port Hudson, Miss.	May 29, 1863	1 year	16 mos.	6 inches	None	1 inch	Healed in good order.
Comp'd com. fracture of knee-j'int	Wilmington, N. C.	Feb. 21, 1865	5 mos.	7 mos.	9 inches	3½ inches	½ inch	Some thickening of the periosteum.
Comp'd com. fracture of tibia, fibula, and femur .	Wilmington, N. C.	Sept. 3, 1864	6 mos.	8 mos.	7½ inches	½ inch increase	3 inches increase	Damaged by extr. sloughs along front and half the stump.
Wound of lower third of thigh .	Antietam, Md.	Sept. 17, 1862	9 mos.	11 mos.	7 inches	⅜ inches	None	—
Destruc. low. third of leg occasioned by sloughing . .	Frederksburg, Va.	Dec. 13, 1862	6 mos.	9 mos.	8½ inches	½ inch	None	Extensive cicatrization.
A com. fract. of the knee, thigh, & leg	Frederksburg, Va.	Dec. 13, 1862	6 mos.	9 mos.	4½ inches	⅜ inches	2 inches	Not healed.
Comp'd com. frac. of upper third of leg and knee-j'nt	Frederksburg, Va.	Dec. 13, 1862	5 mos.	7 mos.	3 inches	None	⅜ inches increase	Stump very short and flexed upon the body.
Comp'd fracture of knee-joint and head of tibia	Frederksburg, Va.	Dec. 13, 1862	8 mos.	11 mos.	12½ inch.	⅜ inches	⅜ inches	Cicatrization extensive, stump unnecessa'ly long for thigh amputation.

TABLE OF ONE HUNDRED AND FIFTY-EIGHT CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
J. K.	76th N. Y.	Machinist	R.	Lower third	Circular	On the field	Two hours	Fragment of shell
W. M.	14th W. Va. Vols.	Sil'rsmith	L.	Middle third	Circular	On the field	Six days	Piece of shell
R. H.	155d Pa. Vols.	Farmer	L.	Lower third	Ant. post. flap	11th Corps hospital	Four days	Minie-ball
C. H. G.	16th Mass.	None	L.	Middle third	Ant. post. flap	On the field	Twenty-fo'r hours	Rifle-ball
A. C.	—	Printer	L.	Middle third	Ant. post. flap	—	One hour	Minie-ball
P. McA.	1st U. S. A.	Laborer	R.	Lower third	Anterior flap	On the field	Five hours	Fragment of shell
R. T.	2d N. Y. Vols.	Farmer	L.	Middle third	Ant. post. flap	Field hospit'l	Two hours and a half	Musket-ball
H. C. M.	12th U. S. Infantry	Captain	L.	Middle third	Circular	On the field	Twenty-fo'r hours	Minie-ball
C. H. B.	11th Maine	Farmer	L.	Lower third	Ant. post. flap	On the field	Two hours	Rifle-ball
J. P.	142d N. Y. Vols.	Farmer	L.	Lower third	Ant. post. flap	On the field	Three hours	Minie-ball
C. S.	7th N. Y. Vols.	Butcher	R.	Middle third	Anterior flap	On the field	Immediately	Piece of shell
R. T. W.	76th Penn.	Farmer	L.	Lower third	Ant. post. flap	—	Two days	Rifle-ball
C. L. F.	8th N. Y. Cavalry	Assistant Assessor	R.	Lower third	Circular	On the field	Half an ho'r	Solid shot
A. A. H.	9th N. Y. Cavalry	Farmer	R.	Middle third	Circular	On the field	Eight hours	Minie-ball
J. H.	79th N. Y.	Flagstone-cutter	L.	Middle third	Circular	On the field	Twenty-one hours	Minie-ball
A. H.	7th N. Y. H. Artill'ry	Glazier	R.	Middle third	Ant. post. flaps	On the field	Forty-eight hours	Minie-ball
U. P.	Venezu'l'n Army	—	R.	Lower third	Circular	—	Five m'aths	Musket-ball
G. L. E.	16th Conn. Vols.	Farmer	L.	Middle third	Circular	—	Two hours	Grape-shot
J. G.	24th N. Y. Vols.	Surveyor	R.	Lower third	Ant. post. flaps	Field hospit'l	Forty-eight hours	Minie-ball
R. L.	176th N. Y. Vols.	Tailor	R.	Lower third	Ant. post. flaps	On the field	Five days	Fragment of shell
J. B.	6th Mo. Vols.	None	L.	Middle third	—	Beaufort, S. C.	Twenty d'ys	Fall of tree
B. B.	22d N. Y. Vols.	Boatman	R.	Middle third	Ant. post. flaps	Field hospit'l	Three hours	Piece of shell
J. W.	157th, or 159th N. Y. Vols.	Carpenter	R.	Lower third	—	On the field	Eighteen hours	Musket-ball
J. S.	3d N. Y. Vols.	Cigar-maker	R.	Middle third	Ant. post. flap	On the field	Twenty-fo'r hours	Minie-ball
E. T.	4th Va. Vols.	Farmer	R.	Lower third	Circular	On the field	Thirty-six hours	Musket-ball
G. W.	34th Mass. Vols.	Farmer	R.	Middle third	Circular	On the field	Seventeen hours	Minie-ball
A. K.	162d N. Y. Vols.	Sash and blindmak.	R.	Lower third	Rectangular flap	On the field	Twelve h'rs	Shell
S. D. S.	7th N. H.	Farmer	L.	Upper third	Circular	Confederate hospital, C. S. C.	Forty hours	Grape-shot

OF RECOVERED AMPUTATION OF THIGH.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Destruction of leg	Gettysburg, Pa.	July 1, 1863	10 mos.	13 mos.	9½ inches	5 inches	3½ inches	Not healed, stump not well covered.
Comp'd com. fracture of knee-j'int	Shenandoah Val.	Aug. 22, 1864	9 mos.	10 mos.	8½ inches	2½ inches	3 inches	Very good.
Comp'd com. fracture of knee-j'int	Gettysburg, Pa.	July 1, 1863	14 mos.	15 mos.	10½ inch.	3 inches	3 inches	Healed, extensive contrac. of flexor muscles.
Comp'd frac. of low. third of femur .	Fair Oaks, Va.	June 18, 1862	7 mos.	11 mos.	6½ inches	2 inches increase	2 inches	Gangrene, convalescing.
Comp'd com. fracture of thigh above knee . .	Bermuda Hundred	June 29, 1864	5 mos.	6 mos.	8 inches	None	None	Healed in good condition.
Comp'd com. fracture of upper half of leg and knee-joint	Bayou Teche, La.	April 12, 1863	7 mos.	10 mos.	9 inches	2 inches	3 inches	Stump good proportions, ant. flap well cicatrized, stump well covered, smooth.
Comp'd fract. lower third of femur .	Fair Oaks, Va.	June 25, 1862	6 mos.	—	6½ inches	None	4½ inches	—
Comp'd com. fracture of thigh . .	Wilderness, Va.	May 5, 1864	7 mos.	10 mos.	7½ inches	1½ inches	2½ inches	Creditable though scanty covering.
Comp'd com. fracture of knee-j'int	Deep Bottom, Va.	July 21, 1864	6 mos.	7 mos.	10½ inch.	1½ inches	2½ inches	Very good.
Comp'nd fracture of knee-joint. .	Bentonville, N. C.	Mch. 19, 1865	7 mos.	7 mos.	9 inches	2 inches	2 inches	Not pr'perly heal'd, otherwise good.
Comp'd com. fract. upper third of leg	Newport News	Mch. 8, 1862	17 mos.	19 mos.	9½ inches	3 inches	2½ inches	Stump well healed, finely covered, cicatrix well h'ck, clean front, a neat stump, full size.
Comp'd com. fracture of the thigh at its lower third and knee-joint	Pocotaligo, S. C.	Oct. 22, 1862	6 mos.	11 mos.	11 inches	¼ inch	1 inch	—
Destruction of leg	Winchester, Va.	Sept. 19, 1864	10 mos.	1 year	9 inches	3 inches	2 inches	Very good, back of end damaged by sloughing.
Comp'd com. fracture of knee . .	Stevensburg, Va.	Oct. 11, 1863	8 mos.	10 mos.	9½ inches	None	2 inches	Healed, badly damaged by sloughings, eczematous.
Comp'nd comminuted fracture of femur	Blue Springs, E. Tenn.	Oct. 10, 1863 June 3, 1864	4 mos.	7 mos.	8 inches	½ inch increase	1 inch increase	St'mp healed, some angular pouting in front.
Comp'd com. fracture of low. third	Coal Harbor, Va.		6 mos.	7 mos.	6½ inches	¼ inch	1½ inches	Healed, very good.
Comp'd com. fracture of upper third of leg . .	—	1861	4 years	4 years	10½ inch.	1 inch increase	2 inches	Healed, insufficient integumental covering.
Comminuted fracture of knee-joint	Suffolk, Va.	April 24, 1863	5 mos.	6 mos.	4 inches	½ inch	2 inches	Healed.
Comp'd com. fracture of knee-j'int	Antietam, Md.	Sept. 17, 1863	1 year	15 mos.	—	1 inch	1 inch	Well healed and sound.
Comp'd com. fract. 4 inch. bel'w knee	Fisher's Hill, Va.	Sept. 22, 1864	10 mos.	1 year	10 inches	½ inch increase	4 inches	Ordinary, healed.
Simple oblique fracture of thigh	Beaufort, S. C.	Feb'y 3, 1865	10 mos.	—	5 inches	None	None	Lack of extension, became sh'rtened and limited.
Comp'd com. fracture of low. third of leg	Antietam, Md.	Sept. 17, 1862	4 mos.	4 mos.	5 inches	None	1½ inch	—
Com. fract. of upper third of leg	Lookout Valley, Tenn.	Oct. 29, 1863	3 mos.	6 mos.	10½ inch.	1 inch	3 inches	Stump not healed.
Comp'd com. fracture of low. third of thigh	Drury's Bluff	May 16, 1864	7 mos.	9 mos.	7 inches	½ inch	3½ inches	Healed, very good.
Comp'nd fracture of knee-joint . .	Cedar Creek, Va.	Oct. 19, 1864	3 mos.	4 mos.	11 inches	1½ inch	1 inch	Healed, very good.
Comp'd com. fracture of low. third of thigh . . .	Winchester, Va.	Sept. 19, 1864	4 mos.	5 mos.	9 inches	1 inch	1 inch	Healed, very thinly covered by cicatrix, caused by retraction.
Comp'd com. fracture of knee-j'int	Port Hudson, La.	June 14, 1863	3 mos.	15 mos.	10 inches	1 inch	1 inch	—
Compound comminuted fracture of thigh . . .	Fort Wagner, S. C.	July 18, 1863	7 mos.	9 mos.	2½ inches	3 inches	1½ inches	Hemorrhage arrested by a cord he had in his pocket, 24 h'rs in a trench, st'mp ins'fficiently covered owing to sloughing, exfoliation, and retraction.

TABLE OF ONE HUNDRED AND FIFTY-EIGHT CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
J. B.	100th N. Y. Vols.	Moulder	L.	Lower third	Anterior flap	Morris Island	One hour	Fragment of shell
W. H. H.	17th Mich. Vols.	Farmer	R.	Middle third	Circular	On the field	Eighteen hours	Minie-ball
J. M.	11th N. Y. Cavalry	Seaman	L.	Middle third	Ant. post. flap	—	Twenty-fo'r hours	Minie-ball
H. W.	U. S. Navy	Landsm'n	L.	Middle third	Circular	U. S. Hosp., Norfolk, Va.	Forty-eight days	Fragment of shell
P. S.	40th N. Y. Vols.	Cabinet-maker	R.	Upper third	Circular	On the field	Six hours	Minie-ball
P. D.	3d N. Y. Cavalry	Shoe-maker.	L.	Upper third	Circular	On the field	Two hours	Musket-ball
E. J.	117th N. Y. Vols.	Stone-mason	L.	Lower third	Circular	On the field	Seven hours	Grape-shot
D. W. B.	150th N. Y. Vols.	None	R.	Lower third	Circular	On the field	One hour	Minie-ball
J. C.	14th Maine U. S. Inf'y	Gilder	R.	Lower third	Ant. post. flaps	In hospital	Seven hours	Musket-ball
J. McL.	20th Ind. Vols.	Farmer	R.	Lower third	Ant. post. flap	David's Island	Five months and a half	Musket-ball
C. T. D.	3d Maryl'd Vols.	None	L.	Upper third	Circular	Hospit'l, Culpepper C. H.	Three days	Minie-ball
G. W. F.	1st V. H. Artillery	Farmer	R.	Middle third	Circular	Armory Sq. General Hospital	Thirteen days	Minie-ball
P. M.	11th Vt. Vols.	Farmer	L.	Lower third	Ant. post. flaps	On the field	Twenty-fo'r hours	Musket-ball
T. F.	3d N. Y. Vols.	Gardener	R.	Lower third	Ant. post. flaps	On the field	Twelve h'rs	Canister-shot
J. J.	U. S. Navy	Ordinary seaman	L.	Lower third	Circular	Hospit'l ship, Ft. Jackson	Twenty-fo'r hours	Musket-ball
E. W.	U. S. Navy	Coal pass'r	R.	Middle third	Circular	Gunboat, Ft. Jackson	Twenty-fo'r hours	Minie-ball
H. M. C.	10th Conn. Vols.	Gardener	R.	Middle third	Ant. post. flaps	On the field	Immediately	Cannon-ball
C. McD.	2d U. S. Artillery	Bar-tend'r	L.	Middle third	Circular	On the field	Twenty-fo'r hours	Musket-ball
W. A. K.	4th R. I. Vols.	—	R.	Middle third	Ant. post. flaps	On the field	Four hours	Minie-ball
W. S.	Freedm'n's Bureau	—	R.	Lower third	Ant. post. flap	On the field	Two hours	Piece of shell
M. H.	76th N. Y. Vols.	Farmer	R.	Lower third	Circular	Middletown Hospit'l, Md.	Four days 2d time One year	Gunshot
J. L.	6th Conn. Vols.	Sailor	R.	Middle third	Circular	Fortress Monroe	Forty-eight hours	Minie-ball
P. K.	37th N. Y. Vols.	Flagger	L.	Middle third	Ant. post. flap	In 3d Army Corps field hospital	Fifteen days	Rifle-ball
J. H. D.	79th N. Y. Vols.	Salesman	L.	Lower third	Anterior flap	On the field	Immediately	Minie-ball
H. D.	7th Mich.	Farmer	R.	Middle third	Ant. post. flap	On the field	Twenty-fo'r hours	Musket-ball
T. McC.	37th N. Y. Vols.	Bricklayer	R.	Middle third	Ant. post. flap	Steam'r Daniel Webster	Three days	Rifle-ball

OF RECOVERED AMPUTATION OF THIGH.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Destruct. of knee-joint	Fort Wagner, S. C.	July 23, 1863	7 mos.	9 mos.	10 inches	1 inch	2 inches	Stump healed, tender, posterior flap atrophied, bone covered.
Comp'd fracture of thigh at middle third	South Mountain, Va.	Sept. 14, 1862	9 mos.	11 mos.	4½ inches	⅔ inch	1 inch	Stump sound, smooth, efficient.
Comp'd com. fracture of thigh . .	West Louisiana	June 14, 1864	5 mos.	6 mos.	7 inches	2½ inches	2½ inches	Healed, very good.
Comp'd com. fract. of upper third of leg	Gunboat Mendota	July 16, 1864	—	7 mos.	6½ inches	½ inch	1½ inches	End not well cov'd, retraction of muscles, leaving bone exposed.
Comp'und fracture of middle third of thigh . . .	Petersburg, Va.	July 30, 1864	5 mos.	7 mos.	5½ inches	⅔ inch	None	Healed, very short, imperfect.
Comp'und fracture of thigh . . .	Richmond, Va.	May 14, 1864	7 mos.	9 mos.	5 inches	1 inch	1 inch	Healed, poorly covered.
Destruct. of knee-joint	Fort Fisher, N. C.	Jan'y 15, 1865	9 mos.	10 mos.	10½ inch.	increase 3 inches	5½ inches	Very good, considerably injured by two other shots.
Comp'und comminuted fracture of upper third of leg	Culps F'rms, Ga.	June 29, 1864	13 mos.	14 mos.	9 inches	½ inch	5 inches	Very good, nine inches of sequestra.
Comp'und comminuted fracture of knee-joint . .	Baton Rouge, La.	Aug. 5, 1862	10 mos.	11 mos.	11 inches	1 inch increase	4½ inches	Scanty covering, extensive cicatrices adhering to bone.
Comp'und fracture of head of tibia .	David's Island	Dec. 6, 1862	4 mos.	5 mos.	13 inches	2 inches	2 inches	Length excessive, erysipelatous inflammation, abscesses, ulcers, etc.
Comp'und fract. of low. third of thigh	Cedar Mt., Va.	Aug. 9, 1862	5 mos.	—	4½ inches	None	None	Gangrene, not ready.
Comp'und comminuted fracture of knee-joint, complicated with compound fracture of left leg .	Coal Harbor, Va.	June 1, 1864	1 year	13 mos.	7½ inches	2½ inches	2½ inches	Very fair, bone well covered, 4½ inches of bone necrosed, removed whole shaft, periphery, new bone formed, leg bowed, from posterior slough.
Comp'und comminuted fracture of lower third of femur	Coal Harbor, Va.	June 1, 1864	1 year	13 mos.	9½ inches	3 inches	4½ inches	Very good, extensively cicatrized, long flaps.
Comp'und fracture of lower third of thigh	Manassas Gap, Va.	July 23, 1863	7 mos.	13 mos.	9½ inches	1½ inches	3 inches	Stump ulcerated on posterior and upper angle, indications of exfoliat'n, will be efficient.
Comp'und comminuted fracture of knee-joint	Fort Fisher, N. C.	Jan'y 18, 1865	4 mos.	6 mos.	7 inches	None	None	Not healed, on furlough ten days.
Comp'und commi. fracture of lower third of thigh .	Fort Fisher, N. C.	Jan'y 15, 1865	2 mos.	4 mos.	8 inches	2½ inches	½ inch	Excellent.
Destruction of leg	Newbern, N. C.	March 14, 1862	—	—	5½ inches	None	None	—
Wound of knee-joint	San Augusta, Me.	—	—	—	6 inches	2 inches	4 inches	Healthy.
Comp'd com. fracture of knee-j'int	Antietam, Md.	Sept. 17, 1862	14 mos.	16 mos.	9 inches	3 inches	3 inches	Stump sound and vigorous.
Comp'd com. fract. of leg and knee	—	Feb'y 2, 1865	9 mos.	9 mos.	10 inches	3½ inches	5½ inches	Excellent.
Comp'd com. fract. middle of leg, 2d necrosis of femur	South Mountain, Va.	Sept. 18, 1862	17 mos. 2d time 5 mos.	20 mos. 2d time 8 mos.	8 inches	1½ inch	3 inches	St'mp healed nearly, not well cushioned.
Wound of knee-joint	Chester Station	May 10, 1864	5 mos.	6 mos.	8½ inches	2 inches	3½ inches	Healed.
Fract're of the lower part of the femur	Chancellorsville	May 3, 1863	7 mos.	1 year	7 inches	1½ inch	½ inch	Stump pretty fairly cov'd, not healed perfectly, will be good, habits not good, ulcers on other ankle, sore eyes.
Comp'und fracture of knee and leg	Blue Springs, E. Tenn.	Oct. 10, 1863	4 mos.	7 mos.	10½ inch.	None	1½ inches	Walked with assistance half a mile, st'mp not healed, some granulated will be efficient.
Comp'und fracture of knee-joint . .	Fair Oaks, Va.	May 31, 1862	8 mos.	10 mos.	8 inches	½ inches	1½ inches	—
Comp'und fracture of knee-joint . .	Fair Oaks, Va.	May 31, 1862	7 mos. & 24 days	10 mos.	8 inches	2 inches	2 inches	—

TABLE OF ONE HUNDRED AND FIFTY-EIGHT CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
G. S. P.	24th Mass. Vols.	Shoemaker	R.	Upper third	Circular	On the field	Eight hours	Minie-ball
W. S.	3d Artillery	Farmer	R.	Lower third	Ant. post. flaps	Hospital	Three days	Minie-ball
F. O'B.	4th Regiment	Cart-driver	L.	Middle third	Lateral flaps	—	—	Cut with an axe
J. H. D.	3d N. Y. Artillery	Carpenter & joiner	R.	Upper third	Ant. post. flap	Acad. G. H., Newb'n, N.C.	Four weeks	Musket-ball
J. S.	4th N. Y. Vols.	Brewer	R.	Middle third	Ant. post. flap	On the field	Thirty-six hours	Minie-ball
M. M.	69th N. Y. Vols.	Carpenter	R.	Middle third	Ant. post. flap	On the field	Three days	Rifle-ball
D. C.	28th N. Y. Vols.	L'ngsh're-man	L.	Upper third	Circular	On the field	One hour	Solid shot
G. S.	169th N. Y. Vols.	Teamster	R.	Middle third	Ant. post. flap	On the field	Two hours	Canister-shot
G. S.	11th Conn. Vols.	Hatter	L.	Middle third	Ant. post. flap	On the field	Two hours	Minie-ball
F. S.	74th N. Y. Vols.	Clerk	L.	Middle third	Ant. post. flap	Field	Three days	Rifle-ball
J. H.	5th N. J. Vols.	—	L.	Upper third	Circular	On the field	Six days	Minie-ball
J. C.	5th Wis. Vols.	Farmer	L.	Middle third	Ant. post. flaps	David's Isl-and Hospit'l	Fifteen days	Musket-ball
T. D.	88th N. Y. Vols.	Sailor	R.	Middle third	Ant. post. flaps	Field	Six hours	Minie-ball
L. B. B.	26th Iowa Vols.	Farmer	R.	Lower third	Ant. post. flap	Field	Two hours	Minie-ball
D. McC.	2d Mass. Vols.	Shoemaker	R.	Lower third	Ant. post. flap	U. S. Gener'l Hosp. N. H.	Thirteen months	Fragment of shell
F. I.	2d N. J. Vols.	Blacksmith	L.	Middle third	Anterior flap	On the field in corps Hospital	Eighteen hours	Canister-shot
R. W. G.	84th N. Y. S. M.	Painter	R.	Lower third	Ant. post. flap	In field hospital	Thirty hours	Minie-ball
G. M.	40th N. Y. Vols.	Varnisher	R.	Lower third	Rectangular flap	On the field	Second day	Shell
J. T.	14th N. Y. Vols.	Broker	L.	Lower third	Circular	On the field	Twenty-fo'r hours	Minie-ball
T. H. W.	13th N. J. Vols.	Hatter	L.	Lower third	Ant. post. flap	On the field	Three hours	Minie-ball
J. A.	54th N. Y. Vols.	Sailor	L.	Middle third	Ant. post. flap	At field hospital	Eight days	Minie-ball necrosis
J. C.	104th N. Y. Vols.	None	L.	Upper third	Circular	—	Four days	Minie-ball

OF RECOVERED AMPUTATION OF THIGH.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'und comminuted fracture of the middle of the thigh	Seabrook Island, S. C.	April 11, 1863	4 mos.	8 mos.	4½ inches	½ inch	1 inch	Stump not entirely healed, periosteum, some thickened, short, and flexed.
Wound of knee-joint	Washington, N. C.	Sept. 9,	—	11 mos.	8½ inches	2 inches	3 inches	Stump healed.
Wound of knee .	Baltim're, Md.	March, 1862	14 mos.	15 mos.	7 inches	2½ inches	3 inches	Inflammation and gangrene ensued.
Comp'd com. fracture of femur	Kinston, N. C.	Dec. 14, 1862	4 mos.	8 mos.	4½ inches	2½ inches increase	2 inches increase	Stump not healed.
Comp'und fracture of knee	Antietam, Md.	Sept. 17, 1862	9 mos.	11 mos.	8 inches	1 inch	2 inches	St'mp uneven, having sloughed, cicatrices large, small ulcers remaining.
Comp'und comminuted fracture of lower third of the femur	Antietam, Md.	Sept. 17, 1862	7 mos.	1 year	8 inches	None	1 inch	Secondary hemorrhage ensued, femoral artery ligated, st'mp nearly healed, and pathological conditions fair, exc'pt cicatrix extensive on anterior part.
Destruct. of knee-joint, etc. . . .	Antietam, Md.	Sept. 17, 1862	7 mos.	9 mos.	3½ inches	None	½ inch	—
Comp'und fracture lower third of thigh	Coal Harbor, Va.	June 1, 1864	5 mos.	6 mos.	6¾ inches	2½ inches	2 inches	Damaged by gangrene, healed, bone covered by cicatrix only.
Comp'und comminuted fracture of femur	Drury's Bluff, Va.	May 16, 1864	1 year & 14 mos.	1 year & 5 mos.	6 inches	2½ inches	2½ inches	Very good, some damaged by gangrene.
Comp'und fract. of lower 3d of femur	Williamsburg, Va.	May 8, 1862	8 mos.	1 year	7½ inches	1½ inch increase	1 inch increase	Not ready.
Comp'und fracture of knee-joint . .	Williamsburg, Va.	May 11, 1862	8 mos.	8 mos.	4½ inches	1 inch	None	Ready.
Comp'd fract. lower third of femur	Williamsburg, Va.	June 20, 1862	7 mos.	1 year	5½ inches	2 inches increase	½ inch	—
Comp'und fracture of thigh . . .	Antietam, Md.	Sept. 17, 1862	7 mos.	11 mos.	7 inches	2½ inches	2¾ inches	St'mp nearly ready, not healed, ball passing obliquely from the anterior later'l head of tibia, making its exit above the internal condyles of femur, up the left leg, striking the right thigh middle lower third of femur, causing comp'nd fracture.
Comp'und comminuted fract. lower third thigh . .	Lovejoy Station, Ga.	Sept. 4, 1864	11 mos.	13 mos.	8½ inches	3 inches	3½ inches	Damaged by gangrene, transp'rted one mile, then 4, then 130, not dressed for 4 days, diet very poor.
Destruction of ham	Cedar Mountain, Va.	Sept. 13, 1863	8 mos.	1 year	10 inches	1 inch	3½ inches	Nearly healed, some eczema, angulation.
Comp'und fracture knee and leg . .	Gettysburg, Pa.	July 3, 1863	6 mos.	9 mos.	8¾ inches	2 inches	2 inches	Stump irregularly covered, healed, efficient.
Comp'und comminuted fracture of knee	Gettysburg, Pa.	July 1, 1863	5 mos.	7 mos.	10 inches	3 inches	2 inches	Stump admirable, finely cov'red and proportioned.
Comp'und comminuted fracture of upper third of leg and knee .	Gettysburg, Pa.	July 2, 1863	3 mos.	6 mos.	10¾ inch.	None	1 inch	Stump favorable, clean in front, healed and serviceable.
Comp'und comminuted fracture of knee-joint . . .	Gettysburg, Pa.	July 1, 1863	6 mos.	8 mos.	10½ inch.	2½ inches	2 inches	Stump healed, efficient.
Comp'und comminuted fracture of knee-joint . .	Gettysburg, Pa.	July 3, 1863	6 mos.	9 mos.	11 inches	2½ inches	2¾ inches	Stump well healed, round, smooth, well covered, extensively cicatrized, stitches sloughed out.
Comp'und comminuted fracture of lower third of leg	Gettysburg, Pa.	July 1, 1863	1 year. 2d time 11 mos.	14 mos. 2d time 13 mos.	8 inches	None	1¾ inches	Damaged by sloughing, mainly healed.
Comp'und fracture of the middle of thigh	Gettysburg, Pa.	July 1, 1863	11 mos.	1 year	2 inches	1½ inches increase	None	Some hypertrophy, healed scanty, integumentary covering, some ulceration.

TABLE OF ONE HUNDRED AND FIFTY-EIGHT CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
C. K.	20th N. Y. S. M.	Farmer	R.	Upper third	Circular	Hospital at Gettysburg, Pa.	Seven days	Minie-ball
H. H. E.	16th N. Y.	Farmer	L.	Lower third	Circular	Hospital	Ten days	Gunshot
C. McD.	117th N. Y. Vols.	Clerk	R.	Lower third	Ant. post. flap	On the field	Twenty minutes	Musket-ball
W. S.	15th Ind. Battery	Painter	L.	Lower third	Ant. post. flap	Field	Twenty-fo'r hours	Minie-ball
G. W. S.	14th Conn. Vols.	Salesman	R.	Lower third	Rectangular flap	Field	Tw'nty-one hours	Minie-ball
S. B.	2d N. Y. M. R.	Laborer	R.	Lower third	Ant. post. flaps	On the field	One hour	Musket-ball
G. T.	7th Wis.	Fur-trapper	R.	Lower third	Ant. post. flap	On the field	Twenty-fo'r hours	Fragment of shell
D. B.	97th N. Y. Vols.	None	R.	Lower third	Ant. post. flap	On the field	Tw'nty-one hours	Musket-ball
S. H. P.	7th Wis.	Carpenter	R.	Upper third	Ant. post. flap	On the field	Twenty hours	Minie-ball
J. U.	107th N. Y. Vols.	Farmer	L.	Middle third	Rectangular flap	On the field	Forty-eight hours	Grape-shot
P. T.	24th Mich.	Lumberman	R.	Lower third	Circular	Hospital at Gettysburg, Pa.	Three days	Minie-ball
J. C.	7th Md. Vols.	Miller	L.	Lower third	Circular	On the field	Four hours	Minie-ball
C. J. B.	4th R. I.	Carpenter	L.	Lower third	Anterior flap	On the field	Seven hours	Grape-shot
M. S.	139d Penn.	None	R.	Lower third	Circular	Douglas's Hospital	Six days	Minie-ball
G. P. S.	21st Conn. Vols.	Farmer	R.	Middle third	Ant. post. flap	On the field	Four hours	Minie-ball
W. K. S.	5th Conn. Vols.	Merchant	R.	Lower third	Ant. post. flaps	On the field	Twelve h'rs	Shell
T. K.	40th N. Y. Vols.	Laborer	L.	Lower third	Ant. post. flap	—	Tw'nty-one hours	Rifle-ball
J. H. V.	107th N. Y. Vols.	Farmer	L.	Lower and middle third	Ant. post. flap	On the field	Seven days 2d time Tw'nty-one days	Rifle-ball, 2d time Extensive sloughings and de-n'ded bone
W. M. V.	20th N. Y. Vols.	Cigar-maker	R.	Lower third	Circular	On the field	Five days	Minie-ball
G. W. P.	21st N. J. Vols.	Book-keeper	R.	Middle third	Circular	On the field	Six days	Musket-ball
J. McW.	20th Conn. Vols.	Student	L.	Lower third	Circular	Acquia Cr. Hospital	Twenty-three days	Minie-ball
J. S. L.	5th N. J. Vols.	—	L.	Lower third	Ant. post. flaps	Potomac Hospital	Four days	Minie-ball
J. H.	8th N. J. Vols.	Silver-plater	R.	Lower third	Circular	Armory Sq. H'spital, D. C.	Six weeks	Minie-ball
J. E. C.	16th Conn. Vols.	Farmer	L.	Middle third	Circular	At his home	Four weeks	Minie-ball
H. S.	26th N. Y. Vols.	Farmer	R.	Lower third	Anterior flap	On the field	Thirty ho'rs	Minie-ball
J. G.	26th N. Y. Vols.	B'nk-note printer	L.	Middle third	Lateral flap	On the field	Five days	Minie-ball
M. R.	69d N. Y. Vols.	Shoemaker	R.	Upper third	Circular	On the field	Forty-eight hours	Rifle-ball
J. P.	69th N. Y. Vols.	Soldier	R.	Upper third	Circular	—	—	—
J. G. W.	37th N. Y. Vols.	Salesman	R.	Lower third	Lateral flap	At home	107 days	Gunshot
J. C.	25th N. Y. Vols.	Lather	R.	Upper third	Ant. post. flaps	In camp hospital	Five days	Rifle-ball
C. L.	1st Berdan S. Shooters	—	L.	Lower third	Ant. post. flaps	On the field	Two hours	Grape-shot

OF RECOVERED AMPUTATION OF THIGH.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'und fracture middle third of thigh	Gettysburg, Pa.	July 7, 1863	11 mos.	13 mos.	3 inches	1½ inches	None	Healed, very short, imperfectly covered.
Comp'd com. fracture of patella	Freder'ksburg, Va.	May 3, 1863	8 mos.	13 mos.	None	None	1 inch	Stump damaged by sloughing.
Comp'und comminuted fracture of knee-joint	Petersburg, Va.	July 4, 1864	8 mos.	11 mos.	9½ inches	2½ inches	2½ inches	Very good, some damaged by sloughing.
Comp'd com. fract. low.third of thigh	Petersburg, Va.	June 18, 1864	9 mos.	11 mos.	9 inches	1½ inches	1½ inches	Very good, not perfectly healed.
Comp'und comml. fracture of knee-joint	Petersburg, Va.	Sept. 30, 1864	6 mos.	8 mos.	12 inches	3 inches	3 inches	Very good.
Comp'd com. fracture knee-joint	Petersburg, Va.	July 17, 1864	4 mos.	5 mos.	10 inches	2 inches	2 inches	Healed very good.
Comp'd com. fract. of leg near knee	Petersburg, Va.	June 18, 1864	5 mos.	—	11½ inch.	2½ inches	3 inches	Nearly well.
Comp'und comminuted fracture of knee and leg	Petersburg, Va.	June, 1864	5 mos.	4 mos.	10 inches	¾ inch	None	Healed, very well composed.
Comp'd com. fract. middle of thigh	Petersburg, Va.	M'ch 31, 1865	8 mos.	—	5 inches	½ inch	1 inch increase	Very good.
Comp'd com. fracture of knee-joint	Dallas, Ga.	May 25, 1864	10 mos.	1 year	9½ inches	3½ inches	6½ inches	Excellent covering, excellent.
Comp'und fracture c'ndyle of femur, knee involved	Gettysburg, Pa.	July 1, 1863	7 mos.	11 mos.	7½ inches	None	1½ inches	Indications of mortification, stump ulcerated, will be well shaped.
Comp'd com. fracture knee-joint	Petersburg, Va.	July 18, 1864	6 mos.	7 mos.	9 inches	2 inches	4 inches	Healed very good.
Compound comminuted fracture knee-joint	Petersburg, Va.	July 30, 1864	6 mos.	7 mos.	9 inches	2 inches	3 inches	Heal'd, very good, except injury.
Comp'd com. fracture knee-joint	Petersburg, Va.	M'ch 31, 1865	8 mos.	—	9½ inches	2½ inches	2 inches	Very good.
Comp'd com. fracture knee-joint	Petersburg, Va.	June 25, 1864	8 mos.	10 mos.	6½ inches	4 inches	2 inches	Very good.
Destruc. upper p'rt of leg and knee	Chancellorsville	May 3, 1863	3 mos.	14 mos.	9 inches	1 inch	¾ inches	Not healed.
Comp'und comminuted fracture knee-joint	Chancellorsville	May 4, 1863	13 mos.	—	10 inches	1½ inches	4 inches	Nearly healed, some periostitis, necrosis.
Compound comminuted fracture knee-joint	Chancellorsville	May 3, 1863	11 mos.	14 mos.	8½ inches	3 inches	3½ inches	Stump mainly healed, ulcer on the inferior posterior part, badly cicatrized by sloughing and exfoliations.
Comp'd com. fracture knee-joint	Chancellorsville	May 4, 1863	11 mos.	14 mos.	10½ inch.	3½ inches	1½ inches	Healed.
Compound comminuted fracture knee-joint	Chancellorsville	May 4, 1863	11 mos.	15 mos.	5½ inches	1 inch	2½ inches	Healed, periosteum some thickened, some tenderness, anterior and inferior part, cicatrization.
Compound comminuted fracture knee-joint	Chancellorsville	May 3, 1863	11 mos.	11 mos.	10 inches	1 inch	3½ inches	Stump fair, scantly covered, tenderly healed, will prove efficient.
Fracture	Chancellorsville	May 3, 1863	8 mos.	14 mos.	9½ inches	3 inches	4½ inches	Mortificat'n fourth day after injury.
Comminuted fracture knee-joint	Chancellorsville	May 3, 1863	8 mos.	11 mos.	7½ inches	1 inch	3 inches	Stump healed, good condition.
Comp'und fract're knee-joint	Antietam, Md.	Sept. 17, 1862	11 mos.	1 year & 20 days	9 inches	4½ inches	4 inches	Bone protrudes, covered only with skin, muscles retracted, stump well, secondary.
Comp'd com. fracture of the upper third of leg	Freder'ksburg, Va.	Dec. 13, 1862	1 year	14 mos.	12½ inch.	1 inch	3 inches	Stump imperfectly healed, excessively long.
Comp'und comminuted fracture of lower third of femur	Freder'ksburg, Va.	Dec. 13, 1862	5 mos.	7 mos.	8 inches	½ inch	½ inch	Stump ulcerated over the end of bone, parts granulating, has sloughed badly.
Comp'd com. fract. of lower and middle third of thigh	Antietam, Md.	Sept. 17, 1862	13 mos.	15 mos.	4 inches	None	4 inches	Stump short, well healed, will prove vigorous.
Comp'd fracture of femur	Bull Run, Va.	July, 1861	—	—	3½ inches	None	None	Gangrene.
Comp'd fract. middle third of leg	Bull Run, Va.	July 21, 1861	3 years	3 years & 2 mos.	10 inches	3 inches	3½ inches	Good.
Comp'd fract. lower third of femur	Hanover C. H., Va.	June 2, 1862	7 mos.	10 mos.	3½ inches	None	½ inch	Gangrene, convalescent.
Comp'd fr'ct. knee; destruction of leg	Hanover C. H., Va.	May 27, 1862	8 mos.	9 mos.	8 inches	½ inch	2½ inches	Stump poorly rounded.

TABLE OF ONE HUNDRED AND FIFTY-EIGHT CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
T. G.	38th N. Y. Vols.	Laborer	L.	Middle third	Ant. post. flaps	On the field	Three hours	Grape-shot
R. C.	23d Veteran, Ill.	Builder	R.	Lower third	Ant. post. flaps	On the field	Three hours	Minie-ball
P. R.	3d R. I. Artillery	Laborer	R.	Lower third	Bilateral flaps	In field hospital, Morris Island, S. C.	Two hours and a half	Explosion of torpedo
L. D. P.	5th N. Y. Vols.	Sailor	R.	Middle third	Rectangular flap	Rebel hospital	Twenty-fo'r hours	Minie-ball
A. S.	4th N. H. Vols.	Teamster	L.	Middle third	Lateral flaps	On the field	Five hours	Fragment of shell
F. M.	100th N. Y. Vols.	Farmer	R.	Middle third	Circular	On bo'rd rebel transport, Charleston	Twenty-fo'r hours	Grape-shot
M. K.	1st Vt. Artillery	Farmer	L.	Middle third	Bilateral flaps	On the field	Soon after	Fragment of shell
T. B.	100th N. Y. Vols.	Farmer	R.	Middle third	Ant. post. flaps	Charleston, S. C.	Five days	Grape-shot
G. C.	3d U. S. A. A.	Soldier	R.	Middle third	Ant. post. flap	Bellevue Hospital	One yr. and nine months	Rifle-ball
J. F. W.	Sailor	Sailor	L.	Middle third	Ant. post. flaps	—	—	Gunshot
R. G.	U. S. Navy	Sailor	R.	Middle third	Ant. post. flap	—	—	Gunshot
M. R.	—	Blacksmith	L.	Middle third	Circular	—	—	Pistol-shot
E. K.	3d N. J. Vols.	Moulder	R.	Lower third	Ant. post. flap	On the field	Six days	Rifle-ball
O. P. R.	10th Penn. Reserve	Carpenter	R.	Middle third	Ant. post. flaps	On hosp. ship Louisiana	One month	Rifle-ball
J. B.	7th Ind. & 13th N. Y.	Machinist	R.	Lower third	Bilateral skin-flaps and circular	Hampton Hospital	Sixty-eight days	Upsetting caisson
M. Q.	55th N. Y. Vols.	Laborer	L.	Lower third	Anterior flap	On the field	Immediately	Minie-ball
P. H.	40th N. Y. Vols.	Butcher	R.	Lower third	Anterior flaps	On the field	Four hours	Solid shot
J. M. B.	6th N. Y. Artillery	Seaman	R.	Middle third	Ant. post. flaps	Armory Sq. Hosp., D. C.	Fifteen days	With axe
J. M. T.	36th Ill. Infantry	Lieutenant	L.	Lower third	Ant. post. flap	On the field	Thirty ho'rs	Gunshot
M. S. M.	81st N. Y. Vols.	Furnaceman	L.	Lower third	Ant. post. flaps	On the field	Three hours	Minie-ball
M. J. C.	145th Penn.	None	R.	Middle third	Ant. post. flap	On the field	Half an hour	Fragment of shell
J. H.	1st Texas Cavalry	None	L.	Middle third	Circular	Marine Hospital, N. O.	Soon after injury	Musket-ball
J. H. C.	4th N. Y. Vols.	Teamster	R.	Lower third	Circular	On the field	Thirty-six hours	Shell
C. W.	17th N. Y. Vols.	Tinsmith	L.	Middle third	Ant. post. flaps	Ebenezer Church	Five m'nths	Rifle-ball
C. H. M.	69th N. Y. Vols.	Waiter	R.	Middle third	Circular	Frederick City Hospit'l	Six months and a half	Musket-ball

OF RECOVERED AMPUTATION OF THIGH.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'd com. fract. low. third femur	Malvern Hill, Va.	July 1, 1862	6 mos.	8½ mos.	8½ inches	2 inches	1 inch increase	Not healed.
Compound comminuted fracture upper third of leg	Petersburg, Va.	April 2, 1865	8 mos.	4 mos.	12 inches	½ inch	1½ inch	Disc very good, should have been disarticulation.
Destruction of leg at knee-joint	Morris Island	Sept. 11, 1863	5 mos.	7 mos.	8½ inches	½ inch	None	Stump not healed, will be round and efficient.
Compound comminuted fracture of knee-joint	Petersburg, Va.	Aug. 18, 1864	5 mos.	—	8 inches	1 inch increase	None	Finely formed and covered, swelling on anterior middle of stump, white, painless, size indicative of some disease, 4x3.
Comminuted fracture of knee	Morris Island, S. C.	Sept. 17, 1863	4 mos.	7 mos.	8 inches	2 inches	1 inch	Stump not healed, will be efficient.
Entire leg badly comminuted to knee	Fort Wagner, S. C.	July 19, 1863	10 mos.	1 year	6½ inches	1½ inches	3 inches	Healed, poorly covered, damaged by sloughing.
Destruct. of knee-joint	Port Hudson, La.	May 27, 1863	8 mos.	10 mos.	6 inches	2½ inches increase	3 inches	Stump healed, well covered.
Compound comminuted fracture of middle of leg	Fort Wagner, S. C.	July 18, 1863	8 mos.	7 mos.	9 inches	1 inch	1 inch	Stump healed, periosteum some thickened.
Wound of knee-joint	Utah Territory	June 4, 1860	2 years & 5 mos.	—	7½ inches	1 inch	2 inches	—
—	Ft. Donel. & Philip	1862	—	—	7 inches	None	None	—
—	Ft. Donel. & Philip	1862	—	—	4 inches	2 inches	2 inches	—
—	Hartford, Conn.	Dec. 26, 1861	—	—	9½ inches	1 inch	1 inch	—
Comp'd com. fracture knee-joint	Gaines's Mill, Va.	June 27, 1862	2 years	3 years & 4 mos.	8½ inches	2½ inches	3 inches	Stump not healed, will be very good.
Comp'und fracture lower third of femur	Gaines's Mill, Va.	June 27, 1862	7 mos.	18 mos.	8½ inches	None	None	Not healed.
Comp'und fracture of ankle-joint	Yorkt'wn, Va.	April 30, 1864	7 mos.	9 mos.	10 inches	1½ inches	1 inch	Healed very good.
Comp'und fracture of knee-joint	WhiteOak Swamp	June 27, 1862	6 mos.	—	9½ inches	1½ inch	2½ inches	Atrophy of muscle about union of the flaps, front and end smooth, taken prisoner to Richmond; two months on board Sanitary Ship, then to City Hospital, N. Y.
Destruct. of knee	N. Anna River	May 23, 1864	6 mos.	8 mos.	9½ inches	2 inches	2 inches	Not quite healed, some thickening and exfoliation.
Great toe, erysipelas, gangrene	—	May 27, 1864	6 mos.	7 mos.	9½ inches	2½ inches	3 inches	Nearly healed.
Comp'd fracture of knee-joint	—	May 28, 1864	8 mos.	8 mos.	12 inches	1 inch	1½ inch	Healthy, united by first intention.
Compound comminuted fracture of lower third of thigh	—	May 9, 1864	8 mos.	10 mos.	8 inches	1 inch	3 inches	Extensive necrosis, healed, extensively cicatrized, excessive incisions.
Comminuted fracture of knee-joint	—	Oct. 14, 1863	8 mos.	1 year	7 inches	1½ inch	1½ inch	Healthy.
Wound of popliteal artery	Hudson City, La.	Sept. 1, 1863	7 mos.	10 mos.	8 inches	2 inches	3 inches	Stump healed, some irregular, efficient.
Comp'd com. fract. of entire leg	Freder'ks-burg, Va.	Dec. 13, 1862	9 mos.	1 year	10½ inch.	2½ inches	3 inches	Stump healed.
Comp'und fracture of knee-joint	Bull Run, Va.	Aug. 30, 1862	10 mos.	1 year & 28 days	8 inches	3 inches	1 inch	Stump bruised, ulcerated, good condition, habits intemperate, leg badly œdematous
Comp'd fract. upper third of leg and knee	Antietam, Md.	Sept. 17, 1862	11 mos.	1 year & 1 month	10 inches	1½ inch	3 inches	Stump not perfectly healed.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
L. H.	10th U. S. Infantry	Farmer	R.	Lower and middle third	Circular	On the field	Two hours	Rifle-ball
W. R. S.	14th U. S. Infantry	Soldier	R.	1st, low. third 2d, middle & upper third	Ant. post. flap	On the field	One hour 2d, forty-one days	Fragment of shell Necrosis
G. K.	140th N. Y. Vols.	Bricklayer	R.	Upper and middle	Posterior flap	Fredericksburg hospital	Sixth day	Grape-shot
P. D.	170th N. Y. Vols.	Blacksmith	L.	Upper and middle third	Ant. post. flap	City Point Hospital	Five days	Musket-ball
P. S.	39th N. Y. Vols.	Farmer	L.	Middle and upper third	Posterior flap	Hampton Hospital	Fourteen days	Musket-ball
S. B. D.	15th N. Y. Vols.	Farmer	L.	Lower third	Ant. post. flaps	On the field	Nine hours	Minie-ball
H. P.	39th N. Y. Vols.	Farmer	L.	Lower third	Circular	Brooklyn, N. Y.	Seventy-seven days	Two musket-balls
F. P. B.	36th Mass. Vols.	Moulder	L.	1st, lower and middle third 2d, middle third	Bilateral skin flaps Circular	On the field	Twelve h'rs 2d, seven months	Musket-ball Necrosis of tibia
T. L.	10th N. Y. Vols.	Ship-carpenter	R.	Lower third	Circular	On the field	One hour	Minie-ball
J. M.	10th U. S. Infantry	Farmer	R.	Middle third	Ant. post. flap	On the field	Two hours	Rifle-ball
W. R.	83d N. Y. Vols.	Seaman	R.	Upper third	Circular	On the field	Seventeen hours	Two minie-balls
R. G.	83d N. Y. Vols.	None	R.	Upper third	Ant. post. flap	On the field	Sixteen hours	Fragment of shell
W. C.	5th N. Y. H. Artill'ry	Bricklayer	R.	Upper and middle third	Ant. post. flaps	On the field	Fifteen hours	Minie-ball
F. F.	5th N. Y. Vols.	None	R.	Lower third	1st, post. flap 2d, bilateral flaps	Winchester Hospital	Thirty days 2d, in hospital	Minie-ball
E. D. N.	11th Conn. Vols.	Tinman	L.	Upper and Middle third	Posterior flap	On the field	Eighteen hours	Musket-ball
R. A.	14th U. S. Infantry	Teamster	L.	Upper and middle third	Circular	On the field	Seven days	Rifle-ball
N. D.	61st N. Y. Vols.	Farmer	L.	Middle third	Posterior flap	On the field	Six hours	Minie-ball
P. S.	—	Mechanic	R.	Middle third	Ant. post. flap	Newtown U. S. Hospital	Sixteen days	Minie-ball
G.W.M.	123d N. Y. Vols.	Farmer	L.	Middle and upper third	Ant. post. flap	McDougal General Hospital	Two m'nths and twelve days	Minie-ball
P. B.	74th N. Y. Vols.	Frenchman	R.	Lower and middle third	Circular	On the field	Forty-eight hours	Musket-ball
J. L.	69th N. Y. Vols.	Laborer	R.	Middle and upper third	Circular	—	Three days	Musket-ball
B. M.	109th N. Y. Vols.	Farmer	R.	Lower third	Posterior flap	—	Twenty-fo'r hours	Fragment of shell
J.F.M.R	12th N. C. C. S. A.	Student	R.	Middle and lower third	Circular	On the field	Sixteen hours	Grape-shot
T. P.	2d N. Y. S. M.	Military	L.	Lower and middle third	Circular	Hospital 51st, New York	Thirty days	Minie-ball
D. O'S.	2d U. S. Infantry	Hatter	L.	Upper third	Circular	On the field	Four hours	Solid shot
M. M.	76th N. Y. Vols.	Farmer	R.	Upper and middle third	Circular	C. H. Hospital, Gettysburg, Pa.	Twenty-two days	Minie-ball

OF RECOVERED AMPUTATION OF THE LEG.

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'd com. fract. of leg, lower 3d	Wilderness, Va.	May 6, 1864	5 mos.	—	10½ inch.	½ inch	2½ inches	Not healed, will be good.
Disr'pture of tarso-metatarsus, ankle joint, second necrosis	Wilderness, Va.	May 5, 1864 June 16, 1864	3 mos. 2d, 2 mos.	—	5½ inches	¾ inch increase	½ inch	Not healed, œdematous.
Comp'd com. fracture of low. third of leg	Wilderness, Va.	May 8, 1864	3 mos.	7 mos.	4½ inches	None	2 inches	Healed badly, composed, redundant flap.
Comp'und fracture of tarsus	Petersburg, Va.	June 16, 1864	5 mos.	6 mos.	7 inches	2½ inches	2½ inches	Healed, some damaged by exfoliations.
Comp'd com. fracture of leg above malleoli	Petersburg, Va.	July 13, 1864	4 mos.	5 mos.	8 inches	¼ inch	2½ inches	Healed, crest cicatrized, flap separated, pendulous, limb very good.
Comp'und fracture of ankle joint	Spottsylvania, Va.	May 12, 1864	10 mos.	1 year	11¾ inch.	½ inch	3 inches	Long, damaged by gangrene.
Comp'd com. fract. of tarso-metatarsal bones, thro' the metatarsus and tarsus	Spottsylvania, Va.	May 17, 1864	9 mos.	1 year	11½ inch.	None	2½ inches	Not entirely heal'd, very long, should have been Syme's.
Flesh wound in front of ankle joint by a spent ball, no fracture, ball lodged in muscles, walked a mile	Spottsylvania, Va.	May, 1864	9 mos.	10 mos.	1st, 10¾ inches 2d, 7¾ inches	¾ inch	3½ inches	First very bad, ulceration, necrosis, second, very fine.
Comp'und fract. of calcaneum, ball lodged in it	Spottsylvania, Va.	May 10, 1864	6 mos.	7 mos.	13 inches atr'phied	1 inch	2½ inches	Good, should have been Syme's.
Comp'd com. fracture of leg, middle third	Spottsylvania, Va.	May 9, 1864	5 mos.	8 mos.	7½ inches	2 inches increase	None	Healed, enlarged, damaged, posterior flap redundant.
Comp'd com. fracture middle and lower third	Spottsylvania, Va.	May 11, 1864	3 mos.	4 mos.	4½ inches	1 inch increase	1½ inches	Healed, some damaged by ulceration, flexed.
Middle third of leg	Spottsylvania, Va.	May 11, 1864	3 mos.	5 mos.	3½ inches	½ inch	3 inches	Healed, fair stump.
External malleoli shattered	Snicker's Gap, Va.	July 18, 1864	11 mos.	14 mos.	2 inches	None	None	Walked four miles after injury, healthy, thinly covered, damaged by sloughs.
Comp'd com. fract. of os calcis and tarsus, necrosis	Snicker's G p, Va.	July 18, 1864	11 mos.	1 year	11 inches	¾ inch	1½ inches	Excellent, model stump.
Comp'd com. fracture of upper middle of leg	Petersburg, Va.	June 16, 1864	6 mos.	11 mos.	4 inches	1½ inches increase	None	Swollen, eczematous.
Comp'und comminuted fracture of ankle joint	Gettysburg, Pa.	July 2, 1863	5 mos.	14 mos.	5½ inches	1 inch	½ inch	Flap st'ughed, st'mp badly ulcerated, will be efficient.
Comp'd com. fract. of middle of leg	Gettysburg, Pa.	July 27, 1863	5 mos.	7 mos.	4½ inches	1 inch	3 inches	Stump ulcerated, redundant flap.
Comp'd com. fract. of ankle joint	Gettysburg, Pa.	July 3, 1863	10 mos.		8 inches	1 inch	3 inches	Good.
Comp'd fracture of fibula only, gangrene, secondary hemorrhage	Gettysburg, Pa.	July 2, 1863	3 mos.	6 mos.	4½ inches	None	3 inches	Stump damaged, flexed, will be cicatrized, efficient.
Comp'd com. fract. of ankl- joint	Gettysburg, Pa.	July 1, 1863	13 mos.	15 mos.	8½ inches	¾ inch	4 inches	Not healed, some exfoliation.
Comp'und comminuted fracture of leg	Gettysburg, Pa.	July 5, 1863	—	13 mos.	4½ inches	None	2½ inches	Healed, much damaged by sloughing, and cic'trizations on ant. part
Disrupture of ankle joint	Gettysburg, Pa.	July 4, 1863	11 mos.	13 mos.	10 inches	1½ inches	4 inches	Healed, damaged by sloughing.
Disrupture of ankle joint	Gettysburg, Pa.	July 1, 1863	2 yrs. & 4 mos.	2 yrs. & 5 mos.	7½ inches	¾ inch	3½ inches	Excellent.
Comp'und comminuted fracture of tarsus	Gettysburg, Pa.	July 2, 1863	2 years	2 years	9 inches	None	2½ inches	Healed very good
Destruction at its middle third	Gettysburg, Pa.	July 2, 1863	5 mos.	7 mos.	1½ inches	Knee	support	A good st'mp, flexed at nearly right angles, smooth and clean front for base of support, not perfectly healed, scabbed over.
Compound comminuted fracture of middle third of leg	Gettysburg, Pa.	July 1, 1863	3 mos.	6 mos.	5 inches	¼ inch increase	1 inch	Stump not quite healed, will be smooth and efficient.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
J. W.	14th N. Y. S. M.	Stone-cutter	R.	Lower third	Ant. post. flaps	On the field	One hour	Shell
G. M.	12th N. Y. Regulars	Heating	L.	Lower third	—	U. S. Hospital, Newark	Five days	Railroad accident
J. S. R.	Cavalry	R.R. Telegraph Superintendent	L.	Middle third	Circu ar	—	Two hours	Fragment of shell
R. S.	4th R. I. Vols.	None	L.	Middle third	Posterior flap	On the field	Twenty-six hours	Grape-shot
T. A. S.	5th Conn.	Mechanic	R.	Lower third	Ant. post. flap	Field hospital	Two days	Minie-ball
T. M.	5th Ohio Vols.	Steamboatman	R.	Upper third	Ant. post. flap	Hospital, Culpepper C. H.	Ten days	Minie-ball
J. O'L.	8th Infantry	None	L.	Upper third	Ant. post. flap	Alexandria Gen'l Hosp.	Five days	Piece of shell
A. C. H.	28th N. Y. Vols.	Farmer	R.	Upper third	Circular	Culpepper C. H. Hospital	Three days	Minie-ball
J. F. C.	7th Maine Vols.	Cotton spinner	R.	Lower third	Ant. post. flap	On the field	Six hours	Musket-ball
C. H.	65th N. Y. Vols.	—	R.	Upper third	Circular	On the field	Twenty-fo'r hours	Minie-ball
P. McL.	29th Maine	Farmer	L.	Middle third	Circular	On the field	Thirty h'rs	Minie-ball
J. S. S.	9th H. A.	Farmer	R.	Upper third	Posterior flap	On the field	Thirty h'rs	Minie-ball
J. M.	18th Penn. Cavalry	None	R.	Middle third	Circular	On the field	Fifty-five hours	Fragment of shell
W.G. H.	30th Mass. Vols.	House-painter	L.	Lower and middle third	Ant. post. flaps	On the field	Eight hours	Musket-ball
P. McH.	34th Mass. Vols.	Carder of cotton	L.	Upper third	Posterior flap	On the field	Two hours	Fragment of shell
W.S.W.	Confed'rate	Regular army	L.	Junction up. & middle 3d	Circular	Bermuda Hundred	—	Gunshot
C. P.	U. S. Navy	Sailor	R.	Upper and middle third	Ant. post. flap	Brooklyn	Twenty-two days	Piece of shell
T. B.	54th N. Y. Vols.	Seaman	R.	Middle and upper third	Ant. post. flap	Hilton Head Hospital	Eighty-five days	Musket-ball
S. R.	55th N. Y. Vols.	None	R.	Lower third	Circular	On board steamer	Fifteen days	Musket-ball
M. T.	38th N. Y. Vols.	Carpenter	L.	Lower third	Lateral flaps	Field hospital	Four hours	By springing back of falling tree
W. G.	29th Conn.	Farmer	L.	Lower third	Circular	On the field	Four hours	Canister-shot
J. W.	56th N. Y.	Farmer	R.	Upper third	Circular	On the field	Three days	Shell
J. K.	12th Mass.	Stone-cutter	R.	Middle and lower third	Posterior flap	On the field	One hour	Railroad cars
C. B.	14th N. Y. Militia	Clerk	L.	Middle and upper third	Posterior flap	On the field	Five days	Musket-ball

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Disevering foot at ankle joint.	Gettysburg, Pa.	July 1, 1863	8 mos.	6 mos.	13 inches	½ inch	2 inches	Stump mainly cicatrized, not entirely, will prove efficient, though redundant.
Comminuted fract. of tibia, tarsal articulations . .	South Brunswick, N.J.	May 10, 1864	5 mos.	—	9½ inches	2 inches increase	½ inch increase	Hypertrophy, nearly healed, œdematous.
Disrupture of leg at lower third . .	Hawx' Shops, Va.	May 28, 1864	4 mos.	—	7½ inches	¾ inch	2½ inches	Some atr'phy, nearly healed, crest protruded, cicatrized, otherwise well made.
Comp'd com. fract. of ankle j'int and lower third of leg	Antietam, Md.	Sept. 17, 1862	14 mos.	17 mos.	7¾ inches	¾ inch	4 inches	Stump ulcerated, dark red, some exfoliation.
Comp'und fracture of lower third of leg above ankle joint	Cedar Mountain, Va.	Aug. 9, 1862	5 mos.	8 mos.	9½ inches 7½ effective	¾ inch	None	Posterior flap pendant, anterior denuded, nearly ready.
Comp'und fracture of lower third of leg	Cedar Mountain, Va.	Aug. 9, 1862	4 mos.	8 mos.	5½ inches	None	½ inch	Cicatrized, exfoliation, abscess in joint, anterior inferior part.
Comp'd com. fract. of leg about the middle	Cedar Mountain, Va.	Aug. 9, 1862	1 mo.	8 mos.	4 inches	½ inch increase	¾ inch	Not healed, ulceration exfoliation on inferior portion, joint inflamed, cicatrized well, exfoliation of tibia.
Comp'und fracture of tibia	Cedar Mountain, Va.	Aug. 9, 1862	4 mos.	—	8½ inches	1 inch	½ inch	Scanty, well heal'd, posteri'r deficient in muscle, some enlargement in knee joint, efficient, serviceable for knee-bearing, six feet high and more.
Comp'd com. fracture of ankle joint	Cedar Creek, Va.	Oct. 13, 1864	5 mos.	8 mos.	12½ inch.	None	2 inches	Healed, very good, can lean a little on the end.
Comp'd com. fracture of middle third of leg . .	Cedar Creek, Va.	Oct. 19, 1864	11 mos.	1 year	8¼ inches	1½ inches	None	Very good for short stump.
Comp'd com. fracture of low. third of leg	Cedar Creek, Va.	Oct. 19, 1864	6 mos.	8 mos.	7¾ inches	None	3 inches	Very good.
Comp'd com. fract. of middle third .	Cedar Creek, Va.	Oct. 19, 1864	6 mos.	8 mos.	5½ inches 3 effective	½ inch	1½ inches	Not entirely healed.
Severe injury of calcaneum . .	Cedar Creek, Va.	Oct. 19, 1864	5 mos.	7 mos.	8¾ inches	1 inch	5 inches	Mainly healed, very good.
Comp'd com. fracture of metatarsus and tarsus .	Cedar Creek, Va.	Oct. 19, 1864	4 mos.	6 mos.	8¾ inches	None	2½ inches	Small ulcer, some exfoliation, will be very fair.
Destruction of leg above joint . .	Cedar Creek, Va.	Oct. 13, 1864	8 mos.	5 mos.	3½ inches	None	None	Enlarged, flap receded, not good, healed, damaged by flap, etc.
—	Bermuda Hundred	May 20, 1864	3 mos.	—	5½ inches	None	None	Excellent.
Comp'd com. fract. lower third of leg	—	Feb. 16, 1865	3 mos.	4 mos.	5 inches	½ inch increase	None	Very good.
Comp'd com. fracture junction of lower and middle third	James' Island, S. C.	July 4, 1864	10 mos.	11 mos.	6 inches	½ inch	2½ inches	Very good.
Comp'd fracture of ankle joint . .	Fair Oaks, Va.	June 15, 1862	5 mos.	—	12 inches	¾ inch	4 inches	Flaps, lateral, st'mp good.
Comp'd fract. ab've ankle joint . .	Fair Oaks, Va.	May 27, 1862	7 mos.	—	10 inches	1 inch	4 inches	Gastrocnemii retracted, stump smooth.
Lower back part of thigh and disrupture of ankle joint	Fair Oaks, Va.	Oct. 27, 1864	13 mos.	—	11 inches	None	4½ inches	Excellent, hard and efficient.
Below the knee .	Fair Oaks, Va.	May 31, 1862	2 years	2 years	4½ inches	2 inches	1½ inches	—
Comp'und comminuted fracture of leg and ankle joint	Manassas, Va.	Aug. 14, 1862	4 mos.	6 mos.	9½ inches	½ inch	2½ inches	Stump not healed, flap pendulous, some damaged by exfoliation and extensive cicatrices.
Comp'd fracture of lower third of leg	Manassas, Va.	Aug. 28, 1862	6 mos.	8 mos.	4½ inches	½ inch	2½ inches	Bad posterior flap, pendulous, badly amputated, sloughing.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
M. C.	2d Conn. H. A.	Moulder	L.	Upper and middle third	Circular	On the field	Five hours	Musket-ball
J. McC.	155th N. Y.	Shoemaker	L.	Lower third	Bilateral flaps	On the field	Six hours	Minie-ball
J. W.	8th N. Y. H. A.	Farmer	L.	Upper third	Posterior flap	On the field	Twenty-fo'r hours	Minie-ball
D. H.	11th Vt. Vols.	Blacksmith	L.	Lower third	Ant. post. flaps	On the field	Three hours	Solid shot
J. M.	39th Mass.	Laborer	R.	Lower and middle third	Posterior flap	Brooklyn Coll'ge Hosp.	Twelve h'rs	Railroad cars
A. D.	1st Regt.	—	L.	Upper third	Ant. post flaps	On the field	Six hours	Grape-shot
W. S.	8th Regt.	Architect	R.	Lower third	Ant. post. flaps	Harrisburg, Va.	Seventeen days	Musket-ball
S. H.	Colored	Seaman	R.	Lower third	Circular	Port Royal, S. C.	—	Rifle-ball
A. G.	—	Seaman	R.	Upper third	Ant. post. flap	On gunboat John P. Jackson	Twenty-fo'r hours	Shot
H. W.	9th N. Y. Vols.	Cabinet-maker	R.	Lower and middle third	Ant. post. flap	Spring Hospital, Md.	Thirty-five days	Piece of shell
E. G. F.	Confederate	—	R.	Lower third	Ant. post. flap	On the field	Twelve h'rs	Musket-ball
G.W. R.	1st Md. Battery	Farmer	R.	Upper third	Ant. post. flaps	On the field	Two hours	Rifle-ball
J. L.	N. Y. Vols.	Cooper	L.	Upper third	Circular	Bellevue Hospital	Thirteen days	Rifle-ball
C. H. S.	3d Maine	Machinist	R.	Middle and upper third	Ant. post. flap	On the field	Half-hour	Cannon-ball
W.F.W.	Confederate	—	L.	Lower third	Circular	—	—	Gunshot
F. W. K.	1st V. H. Artillery	Farmer	R.	1st, just ab've ankle 2d, mid.of leg	Ant. post. flap 2d, circular	On the field 2d, Central Park	Seventeen hours 2d, 3 weeks	Minie-ball 2d,exfol'tion and necrosis
J. S.	10th Vt. Vols.	Farmer	L.	Junction of lower and middle third	Circular	Winchester Church	Four days	Musket-ball
M. D.	14th N. H. Vols.	Farmer	L.	Upper third	Circular	On the field	Sev'nty-seven hours	Grape-shot
M. W.	10th Vt. Vols.	Carpenter	L.	Lower and middle third	Ant. post. flap	On the field	Three hours	Conical-ball
J. W.	8th Conn.	Farmer	R.	1st, amputa. lower third 2d, amputa. upper third	Posterior flap	On the field 2d, Frederick City	Six hours 2d, three months	Musket-ball 2d, exfoliations
W. A. B.	2d Infantry Corps d'Afrique	Tailor	R.	Upper third	Posterior flap	Ship Island, Miss.	Six hours	Rifle-ball
G. W.	Ind. L. I. N. Y.	Laborer	R.	Junction of middle and lower third	Bilateral flaps	In post hospital	Half hour	Explosion of torpedo
B. F. F.	7th N. H. Vols.	Farmer	R.	Upper and middle third	Posterior flap	—	Sixty days	Rifle-ball
G. G.	67th Ohio Vols.	Farmer	R.	Upper third	Ant. post. flap	Charleston Hosp., S. C.	Five days	Musket-ball
W. D.	5th Artillery	Sailor	L.	Upper and middle third	Circular	On the field	Half hour	Piece of shell
J. DeF. (Indian)	Chief of	Omahas	R.	Middle third	Circular	—	—	Rusty nail

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'd com. fracture of ankle j'int	Coal Harbor, Va.	June 1, 1864	7 mos.	8 mos.	6 inches	1½ inch	1½ inches	Good, well healed.
Comp'd com. fracture of ankle j'int	Coal Harbor, Va.	June 3, 1864	6 mos.	7 mos.	14 inches	½ inch	2 inches	Healed, good.
Comp'd com. fract. of middle upper third of leg . .	Coal Harbor, Va.	June 3, 1864	1 year	13 mos.	3 inches	None	None	Indifferent, damaged by g'ngrene, knee support.
Disrupt. and carrying away entire foot	Coal Harbor, Va.	June 2, 1864	11 mos.	13 mos.	10½ inch.	1½ inch	2 inches	Excellent.
Passing over ankle joint	Brooklyn, N. Y.	Dec., 1862	4 mos.	6 mos.	8½ inches	1 inch	4½ inches	—
Comp'd fract. middle third of leg .	Chantilly, Va.	Aug. 29, 1862	5 mos.	7 mos.	4½ inches	None	None	—
Comp'und fracture of ankle joint .	Cross Keys, Va.	June 25, 1862	7 mos.	7 mos.	10½ inch.	1 inch	4½ inches	—
Shattering ankle joint	Port Royal, S. C.	June, 1862	—	—	9 inches	None	None	—
Taking off foot, at the same time wounding other foot	Vicksb'rg, Miss.	June 28, 1863	—	—	—	None	None	—
Dissevering external malleolus, not injuring foot nor the tibia and astragalus at articulation, so that he walked with the aid of a rifle.	Antietam, Md.	Sept. 17, 1862	1 year	1 year & 9 mos.	7 inches	1 inch	2½ inches	Stump in good condition.
Comp'und fracture of ankle joint .	Malvern Hill, Va.	July 1, 1862	5 mos.	—	10 inches	1 inch	4 inches	Clean, well formed stump, tibio-astragaloid articulation, artificial leg.
Comp'und fracture of the middle of leg . . .	Malvern Hill, Va.	July 1, 1862	4 mos.	—	4 inches	None	2 inches	End of stump irregular, flap oblique.
Wounding soft parts, lower parts of belly, gastrocnemii	Malvern Hill, Va.	July 1, 1862	4 mos.	—	3½ inches	¾ inch	1½ inches	Cicatrizn. healthy, well, even, quite efficient, walked to Harrison's Landing, thence to Bellevue per transport, walked about till amputation, secondary hemorrhage.
Lower third of leg severed	Malvern Hill, Va.	July 1, 1862	1 year & 5 mos.	1 year & 5 mos.	2 inches	None	None	Stump good, knee support.
Ankle joint and foot	Malvern Hill, Va.	July 1, 1862	—	6 mos.	9 inches	None	None	Taken prisoner at Malvern Hill, Va.
Comp'und comminuted fracture of ankle joint . .	Winchester, Va.	Sept. 19, 1864	9 mos.	10 mos.	7 inches	¾ inch	3 inches	Very good, covering angular.
Comp'und comminuted fracture of ankle joint . .	Winchester, Va.	Sept. 19, 1864	8 mos.	9 mos.	9½ inches	None	4 inches	Very good, end exposed by sloughing.
Comp'und comminuted fracture of middle of leg . .	Winchester, Va.	Sept. 19, 1864	7 mos.	8 mos.	2½ inches	None	None	Excellent for knee support, flexed.
Comp'und comminuted fracture of lower middle of leg	Winchester, Va.	Sept. 19, 1864	7 mos.	8 mos.	6½ inches	None	3½ inches	Very fair, stump d'maged by sl'ghing.
Comp'und comminuted fracture of ankle joint, abscesses, etc. . .	Antietam, Md.	Sept. 17, 1862	11 mos. 8 mos.	14 mos. 11 mos.	5 inches 3½ effect.	1 inch	3 inches	Stump damaged by exfoliations and sloughings.
Comp'd com. fract. of lower third of leg	East Pascagoula, Miss.	April 9, 1863	7 mos.	14 mos.	4½ inches 3 eff'ctive	1½ inch increase	1½ inches	St'mp some flexed, healed, will be efficient.
Destruction of lower third of leg, gastrocnemii and biceps badly lacerated	Ft. Wagner, S. C.	Sept. 19, 1863	10 mos.	11 mos.	8½ inches	None	3 inches	Healed mainly some exfoliation stump flexed hamstrings rigid.
Comp'und comminuted fracture of ankle joint . .	Ft. Wagner, S. C.	July 13, 1863	9 mos.	1 year	4½ inches	¾ inch	2½ inches	Some strophied, healed, irregular, not well composed.
Comp'und fracture of middle of leg	Ft. Wagner, S. C.	July 21, 1863	11 mos.	13 mos.	3½ inches	1 inch	3½ inches	Healed, flexed, rather short.
Completely carrying away the leg at its middle. .	Sharpsburg, Md.	Sept. 19, 1862	8 mos.	10 mos.	6½ inches	½ inch	4 inches	—
Punctured wound, inflammation .	—	1859	4 years	4 years	6½ inches	None	2 inches	—

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
M. McG.	37th Mass. Vols.	None	R.	Middle third	Circular	On the field	Three hours	Canister-shot
J. D. T.	23d Mass. Vols.	None	L.	Junction of middle and upper third	Circular	In field hospital	Eight days	Grape-shot
R. T.	6th Mich.	Farmer	R.	Upper and middle third	Posterior flap	On the field	Half hour	Shell from Union gun while in rifle-pits
C. M. P.	U. S. R. A.	Lieutenant	L.	Middle and upper third	Bilateral flaps	Residence, New York	Twenty-one months	Rifle-ball
H. B.	40th N. Y. Vols.	Farmer	L.	Upper and middle third	Posterior flap	Cliffborne Hospital	Eight days	Rifle combustible ball
L. H. M.	11th N. Y. Vols.	Clerk	L.	Upper third	Ant. post. flap	Rebel hosp., Richmond	Four days	Gunshot
P. B. C.	14th N. Y. Militia	Blacksmith	L.	Upper third	Ant. post. flap	On the field	Eighteen hours	Minie-ball
W. S.	1st Ellsworth Zouaves	Butcher	L.	Lower third	Circular	Bellevue Hospital	Eleven months	Rifle-ball
L. H. M.	—	—	L.	Upper third	Posterior flap	—	—	Shot
E. LeG.	23d N. Y. Vols.	Shoemaker	L.	Upper third	Ant. post. flap	On the field	Forty-eight hours	Minie-ball
J. R.	20th Conn. Vols.	Farmer	R.	Lower and middle third	Ant. post. flap	On the field	Three days	Fragment of shell
C. W. R.	1st R. I. A.	Carpenter	L.	Lower and middle third	Posterior flap	Portsmouth Grove Hospital	Ten months	Minie-ball
H. T.	6th Maine	Fireman	L.	Upper third	Circular	McDougal U. S. Gener'l Hospital	Four mos.	Musket-ball
H. A. G.	11th Vt. Vols.	Farmer	L.	Lower and middle third	Ant. post. flaps	On the field	Eighteen hours	Musket-ball
A. C.	1st U. S. Artillery	Shoemaker	L.	Junction of middle and upper third	Circular	On the field	Half hour	Fragment of shell
J. H. W.	1st La. Infantry	Negro driver	R.	Upper third	Posterior flap	On the field	Half hour	Grape-shot
M. F. P.	131st N. Y. Vols.	Carpenter	R.	Lower third	Circular	On the field	Half hour	Minie-ball
H. C.	167th Penn. Vols.	Railroad Conduct'r	R.	Middle third	—	—	Five hours	Canister-shot
H. G.	88th Ill. Infantry	Railroad Manager	R.	Lower third	Anterior flap	In the field hospital	Seven weeks	Erysipelas from cut
F. M. J.	5th N. Y. Vols.	Pianoforte maker	L.	Upper and middle third	Ant. post. flaps	On the field	Twenty-fo'r hours	Grape-shot
W. T.	U. S. Navy	Boatswain's mate	R.	Lower third	Circular	On board ship	Eighteen hours	Caught in turret
C. L.	14th N. Y. Vols.	House-painter	L.	1st, extreme lower third 2d, junct. of low. mid. 3d	1st, Circular 2d, Bilateral flap	On the field 2d, Central Park	Seven months	Piece of shell
J. L.	8th N. Y. Vols.	Carriage-maker	R.	Junc. of upper and middle of leg	Bilateral and Circular	On the field	Seven and a half months Ten hours	Canister-shot
M. G.	10th N. Y. Vols.	None	R.	Middle and lower third	Circular	On the field	Three to four hours	Musket-ball
A. A.	10th N. Y. Vols.	Farmer	L.	Lower and middle third	Ant. post. flap	On the field	Four hours	Fragment of shell

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks.
						Proximal Portion.	Distal Portion.	Generally made at Time of Application of Artificial Limb.
Comp'und comminuted fract. lower third of leg .	Newbern, N. C.	March 14, 1862	13 mos.	14 mos.	6½ inches	1 inch	4½ inches	Has been wearing a leg with rotatory motion at ankle joint, unreliable and unsatisfactory.
Comp'und fracture of lower part of leg and ankle .	Newbern, N. C.	March 14, 1862	1 year	13 mos.	5½ inches	½ inch	1½ inches	Healed.
Comp'd com. fract. lower third of leg, and flesh wound of calf of the other leg . . .	Port Hudson, La.	June 27, 1863	3 mos.	9 mos.	4½ inches	None	1 inch	Stump in bad condition, exfoliation, flap not united, ulceration, etc.
Comp'und fract. of fibula, tibia split, etc.	2d Bull Run, Va.	May 18, 1864	6 weeks	4 mos.	5½ inches	None	None	Healing.
Comp'und comminuted fracture of middle of leg.	Bull Run, Va.	Aug. 28, 1862	7 mos.	9 mos.	5 inches	None	2 inches	Retracted, flexion more than angle of 45 degrees.
Comp'und comminuted fracture of middle third . .	Bull Run, Va.	July, 1861	8 mos.	1 year & 4 mos.	—	3½ inches	—	Stump vigorous, well healed.
Comp'd fract. lower part of leg .	Bull Run, Va.	July 29, 1862	7 mos.	13 mos.	4½ inches	None	1 inch	—
Compound fracture	Bull Run, Va.	July 21, 1861	16 mos.	—	9 inches	½ inch	3 inches	Fine stump.
—	Bull Run, Va.	July 21, 1861	—	—	—	None	None	—
Comp'd com. fract. of middle third .	Chancellorsville	April 29, 1863	8 mos.	11 mos.	5½ inches	1½ inches	2 inches	Stump healed and efficient.
Destruction of leg at lower third .	Chancellorsville	May 3, 1863	9 mos.	13 mos.	8 inches	½ inch	3½ inches	St'mp healed, some damaged by sloughing.
Boring a hole in the tibia antero-posterior without fracture	Fred'icksburg, Va.	Dec. 3, 1863	4 mos.	6 mos.	7 inches	1½ inches	2 inches	Stump healed, flap redundant, pendulous two inches.
Comp'und comminuted fracture of 4th and 5th metatarsal bones, of internal and external cuneiform and calcis . . .	Fred'icksburg, Va.	May 3, 1863	4 mos.	7 mos.	8½ inches	None	2 inches	Stump smooth, neat, efficient, thoro'ly healed.
Comp'd com. fract. of lower third .	Coal Harbor, Va.	June 1, 1864	8 mos.	9 mos.	8½ inches	½ inch	2½ inches	Well healed, excellent.
Severing leg at its middle and lower third	Port Hudson, La.	May 27, 1863	6 mos.	10 mos.	4½ inches	½ inch	2 inches	Stump well healed, will be vigorous, is well formed.
Comp'und comminuted fracture of middle third of leg	Port Hudson, La.	June 14, 1863	5 mos.	14 mos.	4 inches 2½ effective	½ inch increase	1 inch	Flap redundant, cicatrices extensive, angles pouting, healed, scabby, will do pretty good service.
Lodged in foot, entering back external malleolus, making a circuit of foot	Port Hudson, La.	June 3, 1863	5 mos.	15 mos.	12 inches	None	1 inch increase	Stump bad, necrosis of tibia, several ulcers, livid, hypertrophied.
Middle of leg . .	—	June 18, 1864	4 mos.	—	6 inches	None	None	Medium size, swollen, partially healed.
Tarsus metatarsus sundered . . .	—	Jan'y 16, 1864	10 mos.	11 mos.	10 inches	None	None	Good.
Comp'd com. fract. of foot, ankle joint, and lower third of tibia . .	W. Point, Va.	May 8, 1862	6 mos.	—	6 inches	2 inches	4 inches	Stump not healed, subsequent injury, delay.
Comp'd com. fracture of foot, heel, and ankle joint uninjured . .	James River, Va.	Nov. 28, 1864	2 mos.	3 mos.	9½ inches	None	½ inch	Very fine, healed primarily.
Entire destruction of ankle joint, subsequent disease of bone . .	Dilbyt'wn	Oct. 27, 1864	11 mos. 3 mos.	—	11½ inch. 9½ inches	None	2½ inches	Two and one half inches reamputated, not entirely healed, sluggish.
Comp'und fracture of upper middle of leg	Dingle's Mill, S. C.	April 9, 1865	5 mos.	6 mos.	4 inches	½ inch	None	Excellent.
Compound comminuted fracture ankle joint . .	—	M'ch 16, 1865	6 mos.	7 mos.	9½ inches	1½ inches	4½ inches	Excellent.
Comp'd com. fracture of ankle .	Winchester, Va.	Sept. 19, 1864	4 mos.	7 mos.	9 inches	½ inch increase	2½ inches	Healed good.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
A. T.	U. S. Navy	Seaman	R.	1st, just ab've malleoli, 2d, junct. lower & mid. third	Circular	On gunboat 2d, at Memphis	Ten min'tes 2d, Twenty-two days	Musket-ball
T. F. F.	140th N. Y. Vols.	Stone-cutter	L.	Lower and middle third	Bilateral flaps	Field	Six hours	Minie-ball
C. G. S.	4th U. S. Infantry	Farmer	L.	Lower third	Circular	On the field	One hour	Grape-shot
M. M.	5th N. H. Vols.	Farmer	R.	Lower third	Circular	On the field	Five hours	Minie-ball
J. H. H	5th U. S. Artillery	Farmer	R.	Upper third	Anterior flap	On the field	Three hours	Musket-ball
J. A. H	11th Maine	Sailor	L.	Junction of lower and middle third	Circular	On the field	Five hours	Minie-ball
H. T.	11th Penn. Vols.	Farmer	R.	Lower third	Ant. post. flaps	In the field hospital	One hour	Fragment of shell
H. H	84th Penn. Vols.	Black-smith	L.	Lower third	Circular	Beaufort General Hospital	Three days	Fragment of shell
J. H.	118th N. Y. Vols.	Cabinet-maker	R.	Lower third	Circular	Hosp., Morris Island	One hour	Shell
C. C.	61st N. Y. Vols.	Laborer	R.	Lower and middle third	Circular	Frederick City	One month	Musket-ball
J. V.	83d Penn. Vols.	Farmer	L.	Lower and middle third	Circular	On the field	Five days	Musket-ball
J. H.	93d Penn. Vols.	None	R.	Lower third	Posterior flap	On the field	Four hours	Minie-ball
H. C. C.	67th N. Y. Vols.	Farmer	L.	Lower and middle third	Circular	Annapolis Hospital	Six weeks	Minie-ball
H. M.	44th N. Y. Vols.	Cabinet-maker	L.	Upper third	Ant. post. flap	In a farm-house, Woodstock, Va.	Two hours	Musket-ball
H. R.	88th Penn.	Farmer	L.	Middle and upper third	Circular	General Hospital, Newbern, N. C.	Nine hours	Minie-ball
F. F.	1st Class	Fireman on gunbo't Diana	R.	Upper third	Posterior flap	Pattersonville, La.	Two days	Shell
B.W. B.	U. S. L. Artillery	Farmer	R.	Upper and middle third	Ant. post. flap	Portsmouth Hospital	Three mos.	Minie-ball
F. H. B.	44th N. Y. Vols.	Farmer	R.	Junction of lower and middle third	Ant. post. flaps	On the field	Twelve hours	Musket-ball
T. McQ.	69th N. Y. Vols.	Soldier	L.	Middle third	Circular	U. S. Hospital, Baltim're	Two hours	Railroad cars
J. G. M.	—	Warrior	R.	Lower third	Circular	—	—	Gunshot
F. G. F.	Powder boy	—	L.	Upper middle	Circular	—	Four hours	Shell
B. M.	103d N. Y. Vols.	Lock-smith	L.	Lower and middle third	Ant. post. flap	In field hospital	Six hours	Shell
A. K.	4th N. Y. Vols.	Upholsterer	R.	Lower and middle third	Lateral flaps	Field hospital	Three hours	Solid shot

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'd com. fract. of tarso-metatarsus	Red River	Aug. 5, 1864	11 mos.	1 year	9 inches	⅝ inch	1½ inches	Nearly ordinary very good, hardy.
Compound comminuted fracture ankle joint and leg	Poplar Grove, Va.	Sept. 30, 1864	9 mos.	1 year	8 inches	None	None	Not healed, three quarters of an inch of necrosis, bone removed.
Destruction of ankle joint	Antietam, Md.	Sept. 17, 1862	11 mos.	1 year & 2 mos.	9 inches	1½ inches	4 inches	Stump healed.
Comp'd com. fract of ankle joint	Deep Bottom, Va.	July 27, 1864	10 mos.	11 mos.	10½ inch.	½ inch	2½ inches	Excellent.
Comp'd com. fract. middle third leg	Deep Bottom, Va.	Sept. 29, 1864	11 mos.	—	8½ inches	½ inch	2 inches	Excellent.
Comp'und fracture of ankle joint	Deep Bottom, Va.	Aug. 14, 1864	5 mos.	7 mos.	10 inches	1 inch	2½ inches	Good, well except slight ulcer.
Comminuted fracture lower third of leg	Morris Island, S. C.	Aug. 21, 1863	6 mos.	8 mos.	1½ inches	None	3 inches	Stump healed.
Comminuted ankle joint and foot	Morris Island, S. C.	Aug. 29, 1863	5 mos.	13 mos.	12½ inch.	1 inch	2 inches	Stump long, redundant, some inflamed, ulcerated, will be efficient.
Severing leg at ankle	Morris Island, S. C.	Aug. 31, 1863	4 mos.	1 year	12 inches	½ inch	2½ inches	Stump not healed, will be efficient.
Striking leg at junction of lower third, shattering the bone, exit at the heel	Antietam, Md.	Sept. 17, 1862	9 mos.	11 mos.	8½ inches	2½ inches	3 inches	A model stump, healed by first intention, cicatrix hardly perceptible, silver ligatures, stump right proportions.
Comp'und fracture lower third of leg	Fair Oaks, Va.	June 1, 1863	14 mos.	1 year & 5 mos.	9 inches	None	3 inches	Stump healed, some damaged by sloughing.
Comp'd fracture of ankle and lower third of leg	Fair Oaks, Va.	May 31, 1863	14 mos.	1 year & 10 mos.	9½ inches	1 inch	4½ inches	Not healed.
Comp'd com. fract. of ankle joint, ball entering back of internal malleoli, and exit at anterior lateral portion forward of external malleoli.	Fair Oaks, Va.	May 31, 1863	11 mos.	1 year & 5 mos.	8 inches	1½ inches	2½ inches	Ulcer on end.
Comp'd com. fracture middle of leg by accidental discharge of musket	Woodstock, Va.	June 8, 1863	16 mos.	19 mos.	4 inches	½ inch increase	1½ inches	Stump healed.
Comp'd com. fracture of tarsus, entrance tarso-metatarsus, exit posterior external malleolus	Sandy Ridge	April 17, 1863	6 mos.	8 mos.	13 inches	1 inch	3½ inches	Stump smooth, well healed, redundant; query, could parts have been secured from Syme's at ankle, vastly superior.
Entirely severing leg at its middle third	Berwick Bay engagement	M'ch 28, 1863	8 mos.	—	—	—	—	—
Compound comminuted fracture of ankle joint	Drury's Bluff, Va.	May 16, 1864	8 mos.	9 mos.	6½ inches	None	2 inches	Healed, excellent, compact, firm.
Compound fracture of ankle joint	Drury's Bluff, Va.	May 16, 1864	7 mos.	8 mos.	9 inches	½ inch	3 inches	Healed, some damaged by exfoliations.
Comp'd com. fract. of foot and lower part of leg	Baltim're, Md.	July 26, 1861	2 years & 8 mos.	3 years	7½ inches	½ inch	1 inch	—
—	Gen. Porter's staff	June, 1861	—	—	9 inches	1 inch	1 inch	
Comminuted fracture of lower third of leg	Fort St. Phillip & Jackson	April 24, 1862	10 mos.	10 mos.	5 inches	1 inch	None	
At ankle joint, lower third of leg, severing the foot from the leg save a few shreds of tissues	Fredericksburg, Va.	Dec. 13, 1862	4 mos.	8 mos.	7 inches	½ inch	3½ inches	—
Severing the foot from the leg at the lower third, save by some shreds of muscle	Frederˈksburg, Va.	Dec. 13, 1862	4 mos.	—	8½ inches	½ inch	1½ inches	Stump nearly healed.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
A. T.	U. S. Navy	Seaman	R.	1st, just ab've malleoli, 2d, junct. lower & mid. third	Circular	On gunboat 2d, at Memphis	Ten min'tes 2d, Twenty-two days	Musket-ball
T. F. F.	157th N. Y. Vols.	Stone-cutter	L.	Lower and middle third	Bilateral flaps	Field	Six hours	Minie-ball
C. G. S.	4th U. S. Infantry	Farmer	L.	Lower third	Circular	On the field	One hour	Grape-shot
M. M.	5th N. H. Vols.	Farmer	R.	Lower third	Circular	On the field	Five hours	Minie-ball
J. H. H.	38th U. S. Artillery	Farmer	R.	Upper third	Anterior flap	On the field	Three hours	Musket-ball
J. A. H.	11th Maine	Sailor	L.	Junction of lower and middle third	Circular	On the field	Five hours	Minie-ball
R. T.	17th Conn. Vols.	Farmer	R.	Lower third	Ant. post. flaps	In the field hospital	One hour	Fragment of shell
H. B.	85th Penn. Vols.	Black-smith	L.	Lower third	Circular	Beaufort General Hospital	Three days	Fragment of shell
J. S.	100th N. Y. Vols.	Cabinet-maker	R.	Lower third	Circular	Hosp., Morris Island	One hour	Shell
O. C.	63d N. Y. Vols.	Laborer	R.	Lower and middle third	Circular	Frederick City	One month	Musket-ball
J. Y.	83d Penn. Vols.	Farmer	L.	Lower and middle third	Circular	On the field	Five days	Musket-ball
J. S.	93d Penn. Vols.	None	R.	Lower third	Posterior flap	On the field	Four hours	Minie-ball
B. C. C.	67th N. Y. Vols.	Farmer	L.	Lower and middle third	Circular	Annapolis Hospital	Six weeks	Minie-ball
H. M.	48th N. Y. Vols.	Cabinet-maker	L.	Upper third	Ant. post. flap	In a farm-house, Woodstock, Va.	Two hours	Musket-ball
H. R.	85th Penn.	Farmer	L.	Middle and upper third	Circular	General Hospital, Newbern, N. C.	Nine hours	Minie-ball
P. P.	1st Class	Fireman on gunbo't Diana	R.	Upper third	Posterior flap	Pattersonville, La.	Two days	Shell
B.W. B.	U. S. L. Artillery	Farmer	R.	Upper and middle third	Ant. post. flap	Portsmouth Hospital	Three mos.	Minie-ball
F. H. B.	48th N. Y. Vols.	Farmer	R.	Junction of lower and middle third	Ant. post. flaps	On the field	Twelve hours	Musket-ball
T. McQ.	69th N. Y. Vols.	Soldier	L.	Middle third	Circular	U. S. Hospital, Baltim're	Two hours	Railroad cars
J. G. N.	—	Warrior	R.	Lower third	Circular	—	—	Gunshot
F. G. F.	Powder boy	—	L.	Upper middle	Circular	—	Four hours	Shell
R. M.	126d N. Y. Vols.	Lock-smith	L.	Lower and middle third	Ant. post. flap	In field hospital	Six hours	Shell
A. K.	4th N. Y. Vols.	Upholsterer	R.	Lower and middle third	Lateral flaps	Field hospital	Three hours	Solid shot

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'd com. fract. of tarso-metatarsus	Red River	Aug. 5, 1864	11 mos.	1 year	9 inches	⅜ inch	1½ inches	Nearly ordinary very good, hardy.
Compound comminuted fracture ankle joint and leg	Poplar Grove, Va.	Sept. 30, 1864	9 mos.	1 year	8 inches	None	None	Not healed, three quarters of an inch of necrosis, bone removed.
Destruction of ankle joint	Antietam, Md.	Sept. 17, 1862	11 mos.	1 year & 2 mos.	9 inches	1½ inches	4 inches	Stump healed.
Comp'd com. fract of ankle joint	Deep Bottom, Va.	July 27, 1864	10 mos.	11 mos.	10½ inch.	½ inch	2½ inches	Excellent.
Comp'd com. fract. middle third leg	Deep Bottom, Va.	Sept. 29, 1864	11 mos.	—	3½ inches	¼ inch	2 inches	Excellent.
Comp'und fracture of ankle joint	Deep Bottom, Va.	Aug. 14, 1864	5 mos.	7 mos.	10 inches	1 inch	2½ inches	Good, well except slight ulcer.
Comminuted fracture lower third of leg	Morris Island, S. C.	Aug. 21, 1863	6 mos.	8 mos.	1½ inches	None	3 inches	Stump healed.
Comminuted ankle joint and foot	Morris Island, S. C.	Aug. 23, 1863	5 mos.	13 mos.	12½ inch.	1 inch	2 inches	Stump long, redundant, some inflamed, ulcerated, will be efficient.
Severing leg at ankle	Morris Island, S. C.	Aug. 31, 1863	4 mos.	1 year	12 inches	½ inch	2½ inches	Stump not healed, will be efficient.
Striking leg at junction of lower third, shattering the bone, exit at the heel	Antietam, Md.	Sept. 17, 1862	9 mos.	11 mos.	8½ inches	2½ inches	3 inches	A model stump, healed by first intention, cicatrix hardly perceptible, silver ligatures, stump right proportions.
Comp'und fracture lower third of leg	Fair Oaks, Va.	June 1, 1862	14 mos.	1 year & 5 mos.	9 inches	None	3 inches	Stump healed, some damaged by sloughing.
Comp'd fracture of ankle and lower third of leg	Fair Oaks, Va.	May 31, 1862	14 mos.	1 year & 10 mos.	9½ inches	1 inch	4½ inches	Not healed.
Comp'd com. fract. of ankle joint, ball entering back of internal malleoli, and exit at anterior lateral portion forward of external malleoli.	Fair Oaks, Va.	May 31, 1862	11 mos.	1 year & 5 mos.	8 inches	1½ inches	2½ inches	Ulcer on end.
Comp'd com. fracture middle of leg by accidental discharge of musket	Woodstock, Va.	June 3, 1863	16 mos.	19 mos.	4 inches	¼ inch increase	1½ inches	Stump healed.
Comp'd com. fracture of tarsus, entrance tarso-metatarsus, exit posterior external malleolus	Sandy Ridge	April 17, 1863	6 mos.	8 mos.	13 inches	1 inch	3½ inches	Stump smooth, well healed, redundant: query, could parts have been secured from Syme's at ankle, vastly superior.
Entirely severing leg at its middle third	Berwick Bay engagement	M'ch 28, 1863	8 mos.	—	—	—	—	—
Compound comminuted fracture of ankle joint	Drury's Bluff, Va.	May 16, 1864	8 mos.	9 mos.	6½ inches	None	2 inches	Healed, excellent, compact, firm.
Compound fracture of ankle joint	Drury's Bluff, Va.	May 16, 1864	7 mos.	8 mos.	9 inches	¾ inch	3 inches	Healed, some damaged by exfoliations.
Comp'd com. fract. of foot and lower part of leg —	Baltim're, Md.	July 26, 1861	2 years & 8 mos.	3 years	7½ inches	½ inch	1 inch	—
	Gen. Porter's staff	June, 1861	—	—	9 inches	1 inch	1 inch	
Comminuted fracture of lower third of leg	Fort St. Philip & Jackson	April 24, 1862	10 mos.	10 mos.	5 inches	1 inch	None	
At ankle joint, lower third of leg, severing the foot from the leg save a few shreds of tissues	Fredericksburg, Va.	Dec. 13, 1862	4 mos.	8 mos.	7 inches	½ inch	3½ inches	—
Severing the foot from the leg at the lower third, save by some shreds of muscle	Freder'ksburg, Va.	Dec. 13, 1862	4 mos.	—	6½ inches	½ inch	1½ inches	Stump nearly healed.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
D.M. M.	38th N. Y. Vols.	Clerk	R.	Upper third	Ant. post. flap	Field hospital	Five hours 2d operation eleven days	Cannon-ball Extensive sloughings simultaneous with 1st dressing
J. H.	9th N. Y. Vols.	—	R.	Lower and middle third	Circular	On the field	Two hours	Minie-ball
G.W. P.	30th N. Y. Militia	Cabinet-maker	L.	Upper third	Posterior flap	On the field	Three hours	Fragment of shell
F. A. G.	73d N. Y. Vols.	Farmer	L.	Junction of middle and lower third	Ant. post. flaps	General Hospital, Baton Rouge	Twenty-one hours	Minie-ball
M. W.	114th N. Y. Vols.	Artist	R.	Lower third	Bilateral flaps	Hospital	Thirty days	Musket-ball
W. B.	9th N. J. Vols.	Foundry	L.	Upper third	Circular	On the field	Half hour	Solid shot
W.G. B.	U. S. Navy	Boatswain	R.	Lower and middle third	Circular	Naval Hospital, Pensacola, Fla.	Sev'nty-two hours	Explosion of torpedo
R. J. B.	137th N. Y. Vols.	Farmer	R.	1st, middle third 2d, extreme upper third	Ant. post. flap	On the field 2d, in general hospital	Two hours 2d, twenty-three days	Minie-ball
H. R.	16th Ill. Vols.	Bricklayer	L.	Middle third	Circular	On the field	Three hours	Rifle-ball
R. S.	10th Ohio Cavalry	Farmer	R.	Middle third	Posterior flap	On the field	Three hours	Piece of shell
J. R.	U. S. Navy	Ordinary Seaman	R.	Upper third	Bilateral skin-flaps and circular	U. S. gunboat General Jackson Norfolk U. S. Hospital	Twenty-one hours	Musket-ball
H. W.	U. S. Navy	Ordinary seaman	L.	Lower and middle third	Ant. post. flap		Sixteen days	Minie-ball
J. B.	U. S. Navy	Sailor	R.	Middle third	Lateral flaps	Ship Maratanza	1st, one hour 2d, caused by slo'ghing	Shell
A. D.	15th N. Y. Heavy Artillery	Clerk	L.	Lower and middle third	Bilateral skin flaps and circular	On the field	Twelve h'rs	Minie-ball
D. B.	97th N. Y. Vols.	Miller	R.	Lower third	Bilateral flaps	On the field	One day	Grape-shot
J. C.	33d N. Y. Vols.	Cooper	L.	Lower third	Ant. post. flap	On the field	Fifteen hours	Grape-shot
Iota Ma Ge.	Omaha Indian	—	—	—	—	—	—	—
I. O.	11th N. H. Vols.	Farmer & currier	L.	Lower third	Ant. post. flaps	In Falmouth Hospital	Six days	Musket-ball
J. B.	9th N. Y. Vols.	Farmer	L.	Upper third	Circular	On the field	Half hour	Canister-shot
E. E.W.	144th N. Y. Vols.	Carpenter	L.	Upper and middle third	Flap	Union Chapel Hospital	Three days	Rifle-ball
J. McC.	1st D. C. Vols.	Farmer	L.	Lower third	Circular	On the field	Three hours	Fragment of shell
I. L. S.	4th Mich.	None	L.	Upper third	Ant. post. flap	At Savage's Station	Thirty-six hours	Grape-shot
D. B.	1st Penn.	Farmer	R.	Upper third	Flap	On the field	Twenty-fo'r hours	Musket-ball
C. K,	1st Penn. Reserve	None	R.	Middle third	Flap	In field hospital	Three days	Rifle-ball
S. S.	142d N. Y. Vols.	Farmer	L.	Lower third	Circular	De Camp Hospital	Fifteen days	Minie-ball
J. C.	55th N. Y. Vols.	Farmer	L.	Extreme of upper third	Circular	On the field	Three hours	Rifle-ball & buck-shot
W.H.H.	1st Md. Vols.	Farmer	L.	Middle and upper third	Circular	On the field	Twenty hours	Minie-ball
J. N.	U. S. Navy	Seaman	L.	Upper third	Bilateral skin flaps and circular	On Montauk, U.S. gunboat	One hour	Solid shot

OF RECOVERED AMPUTATION OF THE LEG. — (*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'd com. fracture lower half of leg, 2d, exposure of tibia, some exfoliations . .	Freder'ksburg, Va.	Dec. 13, 1863	4 mos.	5 mos.	3½ inches	None	1¼ inches	—
Comp'und commi. fract. lower third	Freder'ksburg, Va.	Dec. 13, 1863	4 mos.	4 mos.	9 inches	¼ inch	2½ inches	—
Severing leg at lower third	Freder'ksburg, Va.	Dec. 13, 1862	5 mos.	7 mos.	3 inches	None	None	Stump spread, adhesion.
Comp'und fracture of tibia, astragalus, etc. . . .	Baton Rouge	July 7, 1863	7 mos.	9 mos.	9 inches	1½ inches	3 inches	Stump mainly healed, pretty good covering and shape, crest cicatrized, abscesses, etc., will prove very good, some œdema.
Near ankle joint .	Cleaning gun	June 25, 1865	7 mos.	13 mos.	—	2 inches	3 inches	Healed by first intention, finely composed.
Severing the leg at lower third .	Goldsb'ro, N. C.	Dec. 17, 1862	9 mos.	1 year	¼ inch	None	2½ inches	Stump healed, sound.
Comp'd com. fracture of ankle joint and foot .	Mobile Bay, Ala.	M'ch 29, 1865	—	5 mos.	9 inches	1½ inches increase	None	Very œdematous, healed, system debilitated.
Comp'd com. fract. of lower third .	Atlanta, Ga.	July 20, 1864 Aug. 12, 1864	9 mos. 8 mos.	11 mos. 10 mos.	9 inches 2½ inches	None	None	Very fair, stump flexed for knee support.
Comp'und comminuted fracture of lower third of leg	Savannah, Ga.	Dec. 13, 1864	3 mos.	5 mos.	7 inches	None	1¼ inches	Very good, scanty covering.
Comp'd com. fract. of leg and ankle joint	Macon, Ga.	Nov. 19, 1864	4 mos.	7 mos.	7 inches	None	None	Will be good, not well cicatrized.
Wound of posterior tibial artery, no fracture . . .	Ft. Fisher N. C.	Jan'y 15, 1865	2 mos.	5 mos.	3 inches	None	None	Not healed, doing well, flexed for knee support.
Compound comminuted fracture of ankle joint .	Fort Fisher, N. C.	Jan'y 15, 1865	6 mos.	9 mos.	8 inches	None	½ inch	Bad, poorly covered, damaged by sloughs.
Comp'und fracture of lower third of leg	Fort Fisher, N. C.	Oct. 11, 1862 Nov. 6, 1862	5 mos. 4 mos.	5 mos. 4 mos.	6¼ inches	3 inches	3 inches	—
Comp'und comminuted fracture of ankle joint . .	Hatcher's Run, Va.	Mar. 31, 1865	5 mos.	6 mos.	8 inches	½ inch increase	2½ inches	Very good, crest exfol'd, sloughed.
Comp'und comminuted fracture of ankle joint . .	Hatcher's Run, Va.	Feb'y 6, 1865	4 mos.	5 mos.	8¼ inches	¾ inch	2¾ inches	Very long, compact, tapering good, healed.
Comp'und comminuted fracture of tarsus	Dallas, Ga.	May 25, 1864	7 mos.	8 mos.	10 inches	½ inch	1½ inches	Healed, very good.
Suppuration, infiltration, and mortification . .	—	—	—	—	—	—	—	—
Comminuted fracture of lower third of leg . .	Rappahannock	Dec. 13, 1862	7 mos.	16 mos.	8 inches	¼ inch	2½ inches	Stump extremely cicatrized.
Carrying away the leg, except a few fibres from upper middle third . .	Roanoke Island, N. C.	Feb'y 8, 1863	16 mos.	17 mos.	3½ inches	None	None	Stump flexed, right angles, partially anchylosed.
Comp'd com. fracture of tibia . .	Falls Ch., Va.	Nov. 29, 1862	8 mos.	10 mos.	6 inches	None	3 inches	—
Entirely destroying the tarsus .	Richmond, Va.	Sept. 29, 1864	5 mos.	6 mos.	10½ inch.	1 inch	3 inches	Finely healed, excellent.
Comp'd com. fract. of middle of leg	Gaines's Mills, Va.	June 28, 1862	9 mos.	10 mos.	4¾ inches 3½ effect.	¼ inch	3 inches	—
Comp'und fracture of ankle joint .	WhiteOak Swamp, Va.	June 30, 1862	5 mos.	—	3¼ inches	¾ inch	3¾ inches	Stump fair, short, defective, prisoner at Richmond.
Comp'und fracture lower third of leg	WhiteOak Swamp	June 30, 1862	1 month	5 mos.	7 inches	None	2½ inches	Stump sloughed, exfoliation.
Comp'd com. fract. of ankle joint .	City Point, Va.	May 25, 1864	7 mos.	9 mos.	10 inches	¾ inch	4 inches	Very good, well formed.
Comp'und comminuted fracture of middle of leg .	Meridian, Miss.	Feb. 15, 1864	11 mos.	1 year	1 inch	None	None	Very good, neat, good knee support.
Comp'd com. fracture of low. third of leg	Mon'casy, Md.	July 9, 1864	5 mos.	6 mos.	3¾ inches	1 inch	3 inches	Healed.
Destroying leg at middle third .	Stono, S. C.	July 9, 1864	5 mos.	6 mos.	3½ inches	None	None	Swollen, not entirely healed, rigidly flexed at right angles, knee support.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
D. T.	42d N. Y. Vols.	Printer	L.	Middle and upper third	Ant. post. flaps	In field hospital	Tw'nty-two days	Rifle-ball
F. R. K.	66th N. Y. Vols.	Barber	R.	Upper and middle third	Lateral flaps	On the field	Two hours	Piece of shell
C. B.	51st N. Y. Vols.	Butcher	L.	Upper third	Ant. post. flap	In field hospital	Twenty-fo'r hours	Musket-ball
J. W.	66th N. Y. Vols.	Cabinet-maker	L.	Upper and middle third	Lateral flaps	In field hospital	Two hours	Rifle-ball
M. W.	169d N. Y. Vols.	Seaman	R.	Junction of lower and middle third	Bilateral flaps	On the field	Two hours	Fragment of shell
C. A. B.	14th N. Y. Vols.	Railroad	R.	Upper and middle	Ant. post. flap	On the field	Three hours	Piece of shell
P. R.	100th N. Y. Vols.	Cigar-maker	R.	Lower and middle third	Circular	Beaufort General Hospital	Four days	Grape-shot
A. W.	6th Conn.	Gilder	L.	Upper third	Circular	Charleston, S. C.	Twenty-fo'r hours	Two canister-shots
J. M.	78th Penn. Vols.	Carpenter	L.	Upper third	Circular	Charleston, S. C.	Forty-eight hours	Minie-ball
M. S.	100th N. Y. Vols.	Laborer	R.	Upper third	Ant. post. flap	On the field	One hour	Shell
F. K.	7th Conn.	Railroad laborer	L.	Upper third	Circular	Confederate hospital, Charleston, S. C.	Ten hours	Grape-shot
R. H. T.	4th R. I. Vols.	Boatman	L.	Upper third	Circular	McDougal Hospital	Eighty-sev-en days	Musket-ball
S. C. R.	2d Penn. H. Artill'ry	Moulder	R.	Lower and middle third	Circular	On the field	Three hours	Fragment of shell
J. H. B.	3d U. S. C. T.	Sailor	R.	Lower and middle third	Ant. post. flap	On the field	Five hours	Fragment of shell
C. B.	1st U. S. C. T.	House-servant	R.	Lower and middle third	Circular	Portsmouth U. S. Hosp'l	Sev'nty-two hours	Grape-shot
M. L.	125th N. Y. Vols.	Livery	R.	Upper third	Ant. post. flap	On the field	Three hours	Piece of shell
W. T.	20th Mich.	Farmer	R.	Upper third	Circular	On the field	Three hours	Minie-ball
G. B.	97th Penn.	Clerk	R.	Lower third	Bilateral skin flaps and circular	Knights Hospital, N. H.	Twenty-fo'r hours	Minie-ball
M. M.	6th Wis. Vols.	2d Lieutenant	R.	Middle third	Bilateral flaps	On the field	Twenty-fo'r hours	Musket-ball
M. P. S.	13th N. Y. Vols.	—	R.	Middle third	Ant. post. flaps	Newtown Hospital, Gettysburg	Sixteen days	Rifle-ball
W. T. M.	49th N. Y. Vols.	Seaman	L.	Upper and middle third	Long post. flap	On the field	Two hours	Piece of shell
H. G.	1st Maine Heavy Artillery	Farmer	L.	Upper third	Ant. post. flap	On the field	Twenty-fo'r hours	Musket-ball
J. R.	7th N. Y. Artillery	Potter	L.	Upper third	Circular	On the field	Twenty-fo'r hours	Grape-shot
R. D. P.	9th N. Y. Artillery	Farmer	L.	Middle third	Ant. post. flap	On the field	Four hours	Minie-ball
T. B.	4th N. Y. H. Artillery	—	L.	Lower and middle third	Ant. post. flaps	On the field	Forty-eight hours	Minie-ball

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'und fracture of upper middle third of leg . .	Antietam, Md.	Sept. 17, 1862	7 mos.	—	—	None	None	Stump healed.
Comp'd com. fracture of low. third of leg	Antietam, Md.	Sept. 6, 1862	6 mos.	6 mos.	6½ inches	½ inch	3 inches	Ligatures removed, crest of tibia prominent.
Comp'und fracture mid. third of leg	Antietam, Md.	Sept. 17, 1862	5 mos.	1 year & 6 mos.	6 inches	3 inches	3 inches	—
Comp'und fracture of lower third of leg	Antietam, Md.	Sept. 17, 1862	5 mos.	8 mos.	6 inches	None	2 inches	—
Destroying foot at tarsus	Deep Bottom, Va.	July 27, 1864	6 mos.	7 mos.	9½ inches	None	2 inches	Healed very good, model stump.
Comp'd com. fract. almost destr'ying low. third of leg	Winchester, Va.	Sept. 19, 1864	15 mos.	—	3½ inches	None	None	Some angles of flaps: in very good condition.
Entrance head of first metatarsal bone, exit beneath external malleolus, comp. com. fracture of tarsus metatarsus, ankle joint not injured . .	Ft. Wagner, S. C.	July 18, 1863	4 mos.	11 mos.	9 inches	1 inch	3 inches	Stump not healed, damaged by gangrene.
Comp'd com. fracture of ankle and middle third of leg	Ft. Wagner, S. C.	July 18, 1863	4 mos.	11 mos.	3 inches 2½ effect.	None	2½ inches	Tibia shortest, st'mp well healed, will prove efficient.
Comp'd com. fracture of leg at middle third. .	Ft. Wagner, S. C.	July 11, 1863	3 mos.	6 mos.	—	None	None	St'mp yet ulc'rated, enlarged, semiflexed, knee support, fine stump, highly creditable.
Disservering leg at its middle third	Ft. Wagner, S. C.	July 18, 1863	3 mos.	7 mos.	4 inches	½ inch increase	1 inch	Stump not yet healed.
Comp'd com. fracture of middle third of leg . .	Ft. Wagner, S. C.	July 11, 1863	3 mos.	6 mos.	3 inches	1 inch increase	1½ inches	Stump healed, tumefied, cicatrices on the crest by exfoliation, one finger off, arm fractured, inferior maxilla fractured.
Comp'und fracture of tibia, wound of tibial artery . .	Petersburg, Va.	July 3, 1864	5 mos.	6 mos.	1 inch	None	None	Very good, knee flexed for knee support.
Comp'd com. fract. of ankle joint .	Petersburg, Va.	July 6, 1864	6 mos.	8 mos.	9½ inches	None	1 inch	Not healthy, eczematous.
Compound com. fracture of ankle joint	Petersburg, Va.	June 21, 1864	7 mos.	8 mos.	9½ inches	½ inch	3 inches	Healed first rate.
Comp'und comminuted fracture of ankle joint	Petersburg, Va.	June 15, 1864	8 mos.	1 year	9½ inches	None	—	Above diseased part unhealthy, exfoliations.
Comp'd com. fracture of middle of leg	Petersburg, Va.	June 17, 1864	8 mos.	9 mos.	3 inches	None	None	Healed irregular, petty posterior flap.
Comp'und fracture of middle third of tibia	Petersburg, Va.	June 18, 1864	8 mos.	9 mos.	3 inches	None	None	Very good, healed, knee support.
Comp'd com. fracture metatarsus, subsequent gangrene	Petersburg, Va.	Jan'y 17, 1864	11 mos.	19 mos.	11½ inch.	None	1½ inches	Not entirely heal'd, some indications of exfoliation, too long.
Comp'und comminuted fracture of ankle joint . .	Gettysburg, Pa.	July 2, 1863	10 mos.	1 year	8 inches	½ inch	4 inches	Eight inches, ordin'te, finely form'd, healthy, finely cicatrized, efficient.
Comp'd fracture of ankle joint . .	Gettysburg, Pa.	July 19, 1863	10 mos.	1 year	8 inches	1 inch	3 inches	Healed, cicatrized, well formed.
Nearly destroying leg at junction of lower and middle third . .	Petersburg, Va.	July 30, 1864	8 mos.	10 mos.	6 inches	½ inch	1½ inches	Pretty good, redundant flap, not strongly cicatrized.
Comp'd com. fracture junction of middle and lower third . . .	Petersburg, Va.	June 18, 1864	9 mos.	10 mos.	3½ inches	None	None	Strongly cicatrized, fibula spread, prominent crest.
Comp'd com. fract. of middle of leg	Petersburg, Va.	June 17, 1864	9 mos.	10 mos.	3 inches	None	None	Very good, smooth, make good knee support.
Comp'd com. fract. of middle of leg	Coal Harbor, Va.	June 8, 1864	18 mos.	—	3½ inches	None	None	Very good.
Comp'd com. fract. of lower third of leg	Coal Harbor, Va.	June 1, 1864	14 mos.	14 mos.	3½ inches	½ inch	3 inches	Very good.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
L. M.	29th Ill.	—	L.	Lower third	Circular	On the field	Two hours	Minie-ball
N. J.	14th N. Y. H. Artill'ry	Farmer	R.	Lower third	Bilateral skin flaps and circular	On the field	Forty-eight hours	Minie-ball
E. C. L.	8th N. J.	Farmer	R.	Upper and middle third	Circular	On the field	Two hours and a half	Fuse shell
J. R.	6th Conn.	Operative	L.	Lower and middle third	Anterior flaps	On the field	Four hours	Minie-ball
J. O'B.	66th N. Y. Vols.	Shoemaker	R.	Lower and middle third	Circular	On the field	Twenty-fo'r hours	Minie-ball
G.W. G.	6th Md. Vols.	Dry-goods clerk	R.	Upper and middle third	Ant. post. flaps	On the field	Five hours	Minie-ball
J. D. P.	148th N. Y. Vols.	Farmer	R.	Lower and middle third	Circular	On the field	Four hours	Musket-ball
F. H.	8th N. Y. H. Artillery	Moulder	L.	Lower third	Bilateral skin flaps and circular	On the field	One hour	Grape-shot
G. P. C.	1st Mass. Heavy Artillery	Wool carding	R.	Upper third	Bilateral flaps	At hospital	Two m'nths	Minie-ball
J. W.	47th Penn. Vols.	Coverlid weaver	R.	Upper third	Posterior flap	Hilton Head Hospital	Three days	Canister-shot
T. D.	1st Excels'r Brigade	Farmer	L.	Upper and middle third*	Ant. post. flap	Steamer Vanderbilt, June 7th	Seven days	Rifle-ball
W. C.	17th N. Y. Vols.	None	L.	Upper third	Ant. post. flap	—	Twenty-fo'r hours	Solid shot
H. McG.	120th N. Y. Vols.	Laborer	L.	Lower third	Circular	On the field	Thirty hours	Piece of shell
W. D.	59th N. Y. Vols.	None	L.	Upper and middle third	Posterior flap	On the field	Twenty-fo'r hours	Minie-ball
A. J. A.	None	Shoemaker	R.	Upper third	Ant. post. flaps	On the field	Three hours	Gunshot
J. D.	79th N. Y. Vols.	Bricklayer	L.	Lower third	Circular	On the field	Four hours	Minie-ball
T. C.	29th N. J.	Waterman	L.	Lower and middle third	Posterior flap	1st, on the field 2d, Fitzhugh Hospital	Two hours Eighteen days	1st, Frag-m'nt of shell 2d, bone exposed by extr'me slo'ghing
E. B.	145th N. Y. Vols.	Driver	L.	Upper third	Posterior flap	In field hospital, Acquia Creek	Fourteen days	Rifle-ball & extensive suppursti'n after 14 d'ys on the field
W. D.	29th N. Y. Vols.	Carver	R.	Lower and middle third	Circular	On the field	Eight days	Minie-ball
F. H.	73d N. Y. Vols.	Clerk	R.	Middle third	Posterior flap	In field hospital	Twenty-fo'r hours	Minie-ball
T. S.	62d N. Y. Vols.	Hemp-dresser	L.	Middle third	Posterior flap	On the field	Nine hours	Musket-ball
J. B.	57th N. Y. Vols.	Bleacher	R.	Middle and upper third	Circular	On the field	Two hours	Minie-ball
P. P.	3d U. S. Infantry	Farmer	L.	Lower third	Circular	On the field	Eight hours	Piece of shell
H. McN.	5th Mass. Vols.	Farmer	L.	Middle third	Circular	On the field	Two hours	Solid shot
J. R. W.	2d Vt. Vols.	Carriage-painter	L.	1st, middle third 2d, upper third	Circular	1st, on the field 2d, At Mount Pleasant Hospital	1st, Twenty-four hours 2d, Thirty-four hours	1st, shell 2d, sloughing and protrusion of bone

* Syme's mode at ankle joint, sloughed.

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'd com. fract. of ankle joint .	Petersburg, Va.	July 30, 1864	16 mos.	—	15 inches	None	2½ inches	Not healed.
Comp'd com. fract. of ankle joint .	Petersburg, Va.	July 30, 1864	15 mos.	16 mos.	10 inches	1 inch	5 inches	Considerably atrophied, excellent.
Destruct. of leg at low. & mid. third	Petersburg, Va.	April 2, 1865	5 mos.	6 mos.	3 inches	None	None	Very good.
Comp'und comminuted fracture of leg	Petersburg, Va.	May 10, 1864	1 year & 3 mos.	16 mos.	7 inches	¾ inch	3½ inches	Some atrophy, four inches of sequestra removed, ¾ shaft of bone cased, new bone, very good.
Comp'd com. fracture of leg and ankle joint.	Petersburg, Va.	June 22, 1864	13 mos.	15 mos.	9 inches	½ inch	2½ inches	Very good, posterior some retracted.
Comp'd com. fract. of middle of leg.	Petersburg, Va.	June 22, 1864	11 mos.	14 mos.	4½ inches	½ inch	2 inches	Very good.
Comp'd com. fract. of ankle joint .	Petersburg, Va.	June 18, 1864	1 year	13 mos.	10½ inch.	1 inch	2½ inches	Some atrophy, very good.
Comp'd com. fract. of ankle joint .	Petersburg, Va.	June 16, 1864	11 mos.	1 year	11½ inch.	1 inch	2 inches	Some atrophy, excellent.
Slight flesh wound middle of leg, gangrene.	Petersburg, Va.	June 16, 1864	10 mos.	1 year	3 inches	None	None	Very good.
Comp'd com. fract. lower third of leg	Pocotaligo, S. C.	Oct. 22, 1862	4 mos.	6 mos.	4½ inches 2½ effective	None	3 inches	Exfoliation, epidemic. flap post. redundant, adhesions now broken up.
Comp'und fracture of tarso and metatarsal bones. .	Fair Oaks, Va.	June 1, 1862	7 mos.	—	6 inches	½ inch	3 inches	—
Destruction of leg at ankle joint .	—	M'ch 17, 1865	6 mos.	—	3½ inches	½ inch	—	Normal, very good.
Removed the foot, ankle joint not stirred	—	Oct. 28, 1864	11 mos.	1 year	10½ inch.	1½ inch	7½ inches	A prisoner three months in Petersburg, one month in Richmond, st'mp firm, heal'd.
Comp'und comminuted fracture of leg	—	Aug. 15, 1864	13 mos.	14 mos.	5 inches	None	None	Bad by sloughings, gangrene, eczema.
Comp'und comminuted fracture .	—	June 23, 1864	—	15 mos.	2 inches	None	2½ inches	Knee flexed for knee support, very good.
Comp'd com. fract. of low. part of leg and ankle joint	Blue Springs, E. Tenn.	Oct. 10, 1863	4 mos.	10 mos.	9 inches	½ inch	1½ inches	Stump not healed, ulcerated.
Comminuted fracture lower third of leg	Chancellorsville, Va.	May 2, 1863	11 mos.	1 year	7 inches	None	None	Stump healed, flap pendulous, exfoliations, extensive cicatrization.
Comp'und comminuted fracture of middle third of leg	Chancellorsville, Va.	May 3, 1863	6 mos.	14 mos.	3 inches	½ inch increase	None	Stump damaged by sloughing.
Comp'd com. fracture ankle joint .	Chancellorsville, Va.	May 2, 1863	5 mos.	18 mos.	8½ inches	½ inch	3 inches	Stump not yet healed, will result favorably.
Comp'd com. fract. of middle of leg .	Chancellorsville	May 3, 1863	8 mos.	10 mos.	6 inches	¾ inch	2½ inches	Stump healed, efficient.
Comp'und comminuted fracture of middle of leg .	Chancellorsville, Va.	May 3, 1863	5 mos.	11 mos.	5 inches 2½ effect.	None	1½ inches	Stump ill conditioned, flap pendulous, extensive cicatrization, mainly healed.
Comp'd com. fracture of middle third of leg . .	Chancellorsville, Va.	May 3, 1863	4 mos.	7 mos.	Knee support	None	None	Stump healthy, condition flexed, clean, good knee support.
Comp'und comminuted fracture of foot and lower part of leg . .	Chancellorsville, Va.	May 1, 1863	4 mos.	6 mos.	10 inches	1 inch	1 inch	Stump healed and well prop'rtioned.
Destruction of leg at lower third .	Chancellorsville, Va.	May 2, 1863	4 mos.	6 mos.	7½ inches	None	2 inches	Stump contracted, caused by flesh wound of hip, involving the flexor muscles of leg, healed.
Nearly severing leg at its lower third	Fred'icksburg, Va.	Dec. 13, 1862	11 mos.	15 mos.	3 inches 2 effect.	½ inch increase	None	Parts nearly healed, badly damaged by abscesses and sloughings below and above knee, stump pretty vigorous.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
G. A. F.	14th Conn. Vols.	Farmer	L.	Lower and middle third	Circular	On the field	Four days	Minie-ball
J. B.	26th N. Y. Vols.	Laborer	R.	Upper and middle third	Circular	On the field	Half hour	Piece of shell
G. E.	7th N. Y. Vols.	Joiner	L.	Upper third	Circular	On the field	Five days	Musket-ball
W. W. M.	20th N. Y. Vols.	—	R.	Lower third	Circular	On the field	Three days	Minie-ball
J. H. M.	2d Vt. Vols.	Farmer	L.	Upper third	Ant. post. flap	In hospital, Frederick City	Two hours	Minie-ball
L. R.	29th N. Y. Vols.	None	R.	Middle third	Ant. post. flaps	Infirm'ry H., Wash., D. C.	Twenty-fo'r hours	Fall
S. T.	22d N. Y. Vols.	Sawyer underman	L.	Upper and middle third	Posterior flap	In field hospital	Three hours	Canister-shot
J. W.	104th N. Y. Vols.	Farmer	R.	Lower third	Ant. post. flaps	On the field	Seven hours	Fragment of shell
H. C. B.	8th Conn.	Baggage-master Hartford Railroad	R.	Lower and middle third	Ant. post. flaps	Willow Springs Hospital	Six weeks	—
W. M.	8th Conn.	Operative	L.	Lower third	Circular	In the field hospital	Three weeks	Minie-ball
F. B.	59th N. Y. Vols.	Painter	R.	Upper third	Ant. post. flap	On the field	Eighteen hours	Rifle-ball
F. H. M.	9th N. Y. Vols.	Clerk	L.	Upper third	Circular	In field hospital, Falmouth, Va.	Eighteen hours	Musket-ball
R. W.	9th N. Y. Vols.	Printer	R.	Middle and lower third	Circular 2d, Bilateral flaps	Stone Hospital 2d, New York	Nine weeks 2d, sev'nteen months	Minie-ball
S. H. G.	18th Conn.	Laborer	L.	Upper third	Posterior flap	On the field	Five hours	Minie-ball
W. H. M.	31st Miss. Vols.	Farmer	L.	Lower third	Ant. post. flaps	On the field	Three hours	Minie-ball
B. B.	75th N. Y. Vols.	Farmer	L.	Middle third	Ant. post. flaps	General Hospital, New Orleans	Eighty-one days	Minie-ball
F. W.	49th Regt.	Sailor	L.	Lower and middle third	Ant. post. flaps	Lee's Mills Hospital	—	Rifle-ball
H. K. D.	114th N. Y. Vols.	Farmer	L.	Upper third	Bilateral skin flaps and circular	Campbell Hospital	Fourteen days	Minie-ball
J. M.	7th Conn. Vols.	Bricklayer	L.	1st, middle third, 2d, upper third	— 2d, ant. post. flaps	U. S. Hospital	Eighteen hours	Grape-shot
H. F. D.	12th N. H.	Shoemaker	R.	Upper third	Ant. post. flap	At Jarvis Hospital, Baltimore	Ten months Twenty-seven days	Minie-ball
F. B.	20th Regt. Invalid Corps	—	R.	Lower third	Ant. post. flaps	On the field	Three hours	Minie-ball
E. M.	12th U. S. Infantry	Laborer	L.	Upper third	Circular	On the field	Twelve hours	Canister-shot
C. W.	45th N. Y. Vols.	Printer	L.	Lower and middle third	Circular	Gettysburg Hospital	Tw'nty-two hours	Fragment of shell
P. J. M	1st R. I. L. Artill'ry	Hatter	R.	Middle third	Posterior flap	On the field	Twelve hours	Musket-ball

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'd com. fract. of lower third of leg	Fred'icksburg, Va.	Dec. 13, 1862	10 mos.	14 mos.	8 inches	1 inch	2 inches	Stump smooth, well modeled, neuralgia, anterior tibial nerve morbidly sensitive.
Comp'und comminuted fracture of lower third of leg	Fred'icksburg, Va.	May 3, 1863	5 mos.	8 mos.	5½ inches	None	1 inch	Stump some damaged by exfoliation, will be efficient.
Comp'd com. fract. of middle third of leg	Fred'icksburg, Va.	Dec. 13, 1862	10 mos.	13 mos.	2½ inches	None	3 inches	Stump all available though short, ulcers on the end.
Comp'd com. fract. of ankle joint .	Fred'icksburg, Va.	Dec. 13, 1862	—	1 year	7¾ inches	2 inches	2¾ inches	Healthy.
Comp'd com. fracture of middle of leg	Fred'icksburg, Va.	May 3, 1863	4 mos.	7 mos.	3½ inches	None	2¾ inches	Stump not healed, will prove efficient.
Comp'und fracture lower third of leg	Mason's Hill	Oct. 2, 1861	—	—	9 inches	¼ inch	1¼ inches	—
Comp'd com. fract. of lower third .	South Mountain	Sept. 14, 1862	7 mos.	9 mos.	4½ inches	None	1¾ inches	—
Entire destruction of the foot at tibia astragalus articulation . . —	Antietam, Md.	Sept. 17, 1862	18 mos.	21 mos.	9 inches	1¾ inches	4½ inches	Stump healed, scarcely sufficient cicatrix.
	Antietam, Md.	Sept. 17, 1862	18 mos.	21 mos.	9 inches	1½ inches	2½ inches	Stump nearly well, circulation sluggish, cold, bluish.
Through ankle joint	Antietam, Md.	Sept. 17, 1862	15 mos.	19 mos.	—	—	—	Stump entirely healed, but looking very blue and tender, general health good.
Comp'und comminuted fracture of middle and lower third of leg .	Fred'icksburg, Va.	May 3, 1863	3 mos.	7 mos.	3½ inches	½ inch increase	1 inch	Stump tumefied, partially flexed, rigid at an angle of 45°, cicatrization extensive.
Comp'und comminuted fracture of middle of leg .	Fred'icksburg, Va.	Dec. 13, 1862	7 mos.	1 year & 5 mos.	3½ inches	None	None	Stump ulcerated, diathesis scrofulous, abscesses, general system impaired, not diseased.
Comp'und comminuted fracture of ankle and tibia .	Fred'icksburg, Va.	Dec. 13, 1862	7 mos.	20 mos.	8½ inches	½ inch	¼ inch	Stump good, tumefied, hard, three ulcers on end.
Comp'd com. fract. of lower third of leg	Piedmont, Va.	June 5, 1864	9 mos.	10 mos.	2½ inches	None	None	Not good, very angular and redundant.
Comp'und comminuted fracture of tarsus anterior to medio-tarsal line	McDonald, Ga.	Nov. 16, 1864	3 mos.	4 mos.	12 inches	None	2 inches	Well cicatrized, very good, excessively long.
Comp'und fracture of ankle joint .	Teche, La.	April 23, 1863	1 year	14 mos.	7½ inches	1 inch	3 inches	Stump healed, to come latter part of May.
Comp'd fract. middle of leg, parts ab've not injured.	Yorkt'wn, Va.	May 12, 1862	7 mos.	7 mos.	9 inches	2¾ inches	2¾ inches	—
Comp'und comminuted fracture of middle of leg .	Petersburg, Va.	June 22, 1864	7 mos.	9 mos.	3 inches	None	None	Healed, flexed, ham-strings rigid, otherwise good, wishes knee support.
Comp'd com. fract. of lower third of leg	Petersburg, Va.	May 14, 1864	14 mos.	15 mos.	4 inches 3 available	½ inch	2¾ inches	Excellent.
Comp'd com. fract. of external ankle and tarsus exclusive of calcane'm	Gettysburg, Pa.	July 2, 1863	9 mos.	1 year	3¾ inches	None	None	St'mp healed, damaged by abscesses, sloughings, exfoliations.
Comp'und comminuted fracture of ankle joint . .	Gettysburg, Pa.	July, 1863	8 mos.	—	11½ inch.	1½ inches	3 inches	Stump neatly formed, healed by first intention.
Comp'und comminuted fracture of middle of leg .	Gettysburg, Pa.	July 2, 1863	7 mos.	11 mos.	3½ inches	None	2½ inches	Stump healed, spread by infiltration, and long angles of cicatrization.
Comminuted fract. of lower third of leg	Gettysburg, Pa.	July 1, 1863	7 mos.	10 mos.	8½ inches	½ inch	3 inches	Stump healed, in pretty good order, damaged by abscesses and exfoliations along line of tibia.
Comp'und fracture of lower third of leg	Chancellorsville, Va.	May 3, 1863	13 mos.	14 mos.	6½ inches	1½ inches	3¾ inches	Healed, badly composed, efficient.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
C. W.	69th N. Y. Vols.	Laborer in sugar-house	R.	Upper third	Circular	On the field	Six days	Fragment of shell
J. H. P.	20th Conn.	Gunsmith	L.	Middle and upper third 2d, middle third	Posterior flap	1st, hospital, Gettysburg, Pa. 2d, Prof. Post, New York	Thirty-four days 2d, Four months	Rifle-ball 2d, sequestrum from dead bone
J. R.	69th N. Y. Vols.	Cabinet-maker	R.	Middle of leg	Circular	On the field	Forty-eight hours	Minie-ball
H. D.	83d N. Y.	Farmer	L.	Lower and middle third	Circular	On the field	Three hours	Grape-shot
D. K.	1st N. Y. Vols.	Iron-worker	R.	Lower third	Circular	On the field	Five hours	Musket-ball
J. W. C.	83d N. Y.	Moulder	R.	Lower third	Circular	On the field	One hour and a half	Minie-ball
J. C.	10th N. Y. Vols.	Laborer	L.	Lower third	Bilateral flaps	—	One hour	Musket-ball
G. H. G.	122d N. Y. Vols.	Carpenter and joiner	L.	Lower third	Circular	Hospital, D. C.	Five weeks	Fragment of shell
T. C.	42d Ill. Infantry	Farmer	L.	Middle and upper third	Circular	—	Two hours	Musket-ball
L. W.	40th Mass. Vols.	Mechanic	R.	Upper third	Circular	Field hospital	One hour	Fragment of shell
S. W. B.	36th N. Y. Vols.	Hatter	R.	Upper third	Ant. post. flaps	Portsmouth Hospital, Va.	Six weeks	Musket-ball
O. S.	9th Vt. Vols.	Farmer	L.	Upper third	Anterior flap	Field hospital	Twenty-fo'r hours	Minie-ball
A. B.	58th Penn. Vols.	Farmer	L.	Upper third	Posterior flap	On the field	Six hours	Piece of shell
B. McD.	6th N. Y. H. A.	Hotel laborer	R.	Lower third	Circular	On the field	Two hours	Minie-ball
W. H. R.	146th N. Y. Vols.	Farmer	R.	Upper third	Ant. post. flap	On the field	Twenty-fo'r hours	Minie-ball
P. O'R.	7th N. Y. H. A.	Clothes-cutter	L.	Upper third	Circular	Douglass Hospital	Six days	Rifle-ball
G. W. R.	11th Penn. Infantry	Shoe-maker	L.	Upper third	Circular	On the field	Twenty-fo'r hours	Minie-ball
R. A. B.	5th Vt. Vols.	Farmer	L.	Upper third	Posterior flap	Field	Seven days	Minie-ball
G. F. T.	10th N. Y. Vols.	Captain	L.	Middle third	Circular	On the field	Seven hours	Minie-ball
A. H.	49th N. Y. Vols.	Farmer	R.	Lower and middle third	Circular	On the field	Two hours	Fragment of shell
J. U.	U. S. Navy	Landsman	R.	Upper third	Bilateral flaps	On board Boney	Twenty-fo'r hours	Musket-ball
P. E.	15th Mass. Vols.	Spinner	L.	Upper third	Ant. post. flap	On the field	Twenty-fo'r hours	Musket-ball
L. S.	73d N. Y. Vols.	Cigar-maker	L.	Middle third	Ant. post. flap	On Knickerbocker	Twenty-five days	Musket-ball
A. W.	20th N. Y. Vols.	Jewel cases	L.	—	Ant. post. flap	On the field	Four hours	Rifle-ball
R. W.	—	Farmer	—	Middle third	—	—	—	Cannon-ball
J. G.	7th Mich.	Laborer	R.	Middle third	Ant. post. flap	Field hospital	Twenty-eight hours	—
E. P. S.	—	Printer	L.	Upper and middle third	Lateral flaps	Navy Hospital, Baltim're	—	Round musket-ball

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comminuted fract. of ankle joint and lower tibia; extensive extravasation, mortification	Gettysburg, Pa.	July 2, 1863	7 mos.	11 mos.	None	None	None	Stump flexed at angle 35°, not entirely healed, crest angular by ulceration, cicatrization will afford knee base of support.
Comminuted fract. of ankle joint and lower part of tibia	Gettysburg, Pa.	July 3, 1863	5 mos. 2d time 2 mos.	9 mos. 2d time 6 mos.	4½ inches	½ inch	2 inches	Flap very good, healed, stump flexed. 45°.
Comminuted lower leg	Gettysburg, Pa.	July 2, 1863	6 mos.	9 mos.	6½ inches	1 inch	¾ inch	Stump insufficiently covered from sloughing, heal'd, tender, will be effective.
Disrupture of leg at ankle joint	Coal Harbor, Va.	June 3, 1864	3 mos.	4 mos.	8 inches	None	None	Healthy, well composed.
Compound comminuted fracture of ankle joint	Coal Harbor, Va.	June 1, 1864	2 mos.	4 mos.	10½ inch.	¼ inch	1 inch	Beautiful stump, very best, healed by first intention.
Comp'd com. fract. of foot and ankle	Coal Harbor, Va.	June 3, 1864	3 mos.	5 mos.	12 inches	1½ inches	2 inches	Some atrophy, nearly healed.
Comp'und fracture of ankle joint	Rapidan	Feb. 6, 1864	2 mos.	5 mos.	12 inches	None	3½ inches	Some atrophied, healed, well formed, etc.
Metatarsus only	Rappahannock	Dec., 1863	—	18 mos.	15 inches inordinate	½ inch	3 inches	Swollen, ulcerated parts inflamed, some exfoliation.
Comminuted fract. of ankle joint	Murfreesboro', Ten.	Dec. 31, 1862	20 mos.	22 mos.	5 inches	½ inch	2½ inches	Healed, well composed.
Comminuted fracture of lower part of leg	Morris Island, S. C.	Aug. 10, 1863	10 mos.	13 mos.	3 inches	None	None	Some ulcerated, eczematous.
Comp'und fracture of upper middle of leg	Fair Oaks, Va.	May 31, 1862	7 mos. & 24 days	10 mos.	2½ inches	None	None	—
Comp'und comminuted fracture of middle of leg	Chapin's Farm, Va.	Sept. 23, 1864	10 mos.	1 year	2 inches	None	None	Very smooth, and even surfaces.
Disrupture of lower half of leg	Chapin's Farm, Va.	Sept. 29, 1864	6 mos.	9 mos.	4½ inches	½ inch increase	½ inch	Very fair.
Comp'd com. fract. of ankle joint	Chapin's Farm, Va.	Oct. 7, 1864	4 mos.	6 mos.	11½ inch.	1 inch	2½ inches	Much atrophied, excellent.
Comp'und comminuted fracture of middle of leg	Wilderness Va.	May 5, 1864	6 mos.	7 mos.	2½ inches	None	None	Healed, short, irregular.
Comp'und comminuted fracture of middle of leg	Wilderness, Va.	May 31, 1861	13 mos.	14 mos.	3 inches	None	None	Very good, damaged some, fibula spread, knee support.
Comp'und comminuted fracture	Wilderness, Va.	May 5, 1864	1 year	14 mos.	3½ inches	None	None	Good, not straight.
Comp'und comminuted fracture of middle of leg	Wilderness, Va.	May 5, 1864	11 mos.	13 mos.	6 inches 3 available	None	2½ inches	Damaged by neglect.
Comp'd com. fracture of ankle, lower third	Wilderness, Va.	May 6, 1864	10 mos.	1 year	8½ inches	½ inch	2½ inches	Very good, damaged somewhat by sloughing.
Comp'und comminuted fracture of ankle joint	Wilderness, Va.	May 6, 1864	8 mos.	9 mos.	7½ inches	None	2 inches	Very good and efficient, has psoas abscess of right femoral region.
Comp'und fracture lower third both legs	Maudm're River, Va.	May 3, 1863	1 year & 3 mos.	1 year & 10 mos.	3 inches	None	1½ inches	Left leg fractured, not healed, right healed, sloughed, partial use, wo'nded leg not flexible at knee more than 45 degrees.
Comp'und fract. of the middle of leg	Antietam, Md.	Sept. 17, 1862	4 mos.	7 mos.	3 inches	¾ inch increase	None	—
Comp'und fracture of ankle joint	Malvern Hill, Va.	July 1, 1862	7 mos.	8 mos.	7 inches	1 inch	3 inches	—
Entering under internal malleoli, exit at low. middle of leg	Antietam, Md.	Sept. 17, 1862	9 mos.	1 year	7½ inches	¾ inch	4½ inches	Good st'mp, sound, some cicatrices by abscesses, exfoliations.
Comminuted fract. through knee	So. Mountain, Va.	Sept. 14, 1862	9 mos.	1 year	6½ inches	¾ inch	1½ inches	—
Comp'd fracture of lower third of leg	Antietam, Md.	Sept. 17, 1862	7 mos.	10 mos.	7 inches	½ inch	2½ inches	Not healed.
Fracture of ankle joint	Gainey's Mills, Va.	July 28, 1862	4 mos.	4 mos.	7½ inches	¾ inch	3¾ inches	Artificial leg applied, semitendinosus and semimembranosus biceps contracted, improving.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
J. G.	18th N. Y. Vols.	Butcher	R.	Upper third	Ant. post. flap	N. Y. City Hospital	—	Railroad cars
T. E.	105th N. Y. Vols.	Laborer	L.	Lower and middle third	Ant. post. flap	On the field	Twenty-fo'r hours	Minie-ball
J. L.	1st Penn. Artillery	Laborer	R.	Upper and middle third	Circular	In field hospital	One hour and a half	Piece of shell
C. L.	8th Penn.	Carpenter	R.	Lower and middle third	Ant. post. flap	In Patent Office Hospital	Eight days	Minie-ball
W. F. B.	24th N. Y. Vols.	Ship-carpenter	L.	Lower third	Circular	On the field	Two hours and a half	Shell
L. W. V.	6th Maine	Farmer	L.	Lower third	Ant. post. flap	On the field	Forty-eight hours	Minie-ball
A. L.	2d R. I. Vols.	Blacksmith	R.	Lower and middle third	Ant. post. flap	Camden Hospital, D. C.	Seventeen days	Rifle-ball
A. L.	9th N. Y. S. Militia	Shipjoiner	L.	Lower and middle third	Ant. post. flap	Lincoln Hospital, D. C.	Fourteen days	Rifle-ball
H. C. B.	9th Maine	Farmer	L.	Upper third	Circular	Charleston Hospital, S. C.	Three days	Grape-shot
T. L.	48th N. Y. Vols.	Laborer	R.	Middle and upper third	Circular	General Hospital, Port Royal, S. C.	Eighteen hours	Grape-shot
L. A. F.	54th Mass.	Hackdriver	L.	Lower third	Ant. post. flap	Hospital at Beaufort, S. C.	Three days	Musket-ball
E. F. B.	76th Penn. Vols.	Tinsmith	L.	Lower third	Circular	In Charleston Hospital	Twenty hours	Musket-ball
W. N.	6th Kansas Vols.	Farmer	L.	Upper and middle third	Ant. post. flap	Camp Taylor	Three days	Minie-ball
R. B.	1st N. Y. M. R.	None	R.	Upper and middle third	Bilateral flaps	U. S. Hospital, Troy	Five months	Burn
E. R.	U. S. gunboat	Landsman	L.	Lower third	Bilateral flaps	U. S. Hospital, Pensacola	Four days	Explosion of torpedo
W. H. S.	9th Penn. Cavalry	Saddler	L.	Upper third	Posterior flap	Field	Ten hours	Minie-ball
L. H. G.	6th Vt. Vols.	Cabinetmaker	L.	Upper third	Circular	On the field	Six days	Minie-ball
S. J.	4th Vt.	Farmer	R.	Lower and middle third	Circular	Harwood Hospital	Thirty days	Minie-ball
J. R. G.	7th R. I. Vols.	Farmer	R.	Lower and middle third	Ant. post. flap	On the field	Six hours	Rifle-ball
J. L. B.	101st N. Y. Vols.	Farmer	R.	Upper and middle third	Posterior flap	On the field	Four days	Musket-ball
J. P.	20th N. Y. Militia	Farmer	R.	Upper third	Circular	Cliffburne Hospital, D. C.	Twelve days	Minie-ball
T. G.	5th N. Y. Vols.	Machinist	L.	Upper and middle third	Circular	On the field	Four hours	Fragment of shell
J. H.	41st N. Y. Vols.	Clerk	L.	Upper third	Circular	Hospital, Georgetown	Fourteen days	Rifle-ball
P. C.	69th N. Y. Vols.	Farmer	R.	Upper third	Ant. post. flap	On the field	Six hours	Shell
C. F. W.	69th N. Y. Vols.	Porter	L.	Lower and middle third	Circular	On the field	Two days	Minie-ball

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Comp'und comminuted fracture .	Gaines's Mills, Va.	June 27, 1862	—	—	3½ inches	None	None	Extravasation, etc.
Comp'd com. fract. of lower third of leg	Freder'ksburg, Va.	Dec. 13, 1862	4 mos.	6 mos.	10 inches	¼ inch	3 inches	—
Severing the tibia and fibula and entire front part of the leg at its lower third . .	Freder'ksburg, Va.	Dec. 13, 1862	4 mos.	6 mos.	5 inches	None	1¾ inches	Soleus and gastrocnemius muscles entire.
Comp'd com. fract. of ankle j'int and low. third of tibia	Freder'ksburg, Va.	Dec. 13, 1862	4 mos.	10 mos.	8¾ inches	None	3½ inches	—
Destruction of foot at ankle joint, etc.	Freder'ksburg, Va.	Dec. 13, 1862	8 mos.	1 year & 11 mos.	10½ inch.	½ inch	4¾ inches	Good proportions, healed.
Comp'd com. fract. of lower third of leg	Freder'ksburg, Va.	May 3, 1862	3 mos.	5 mos.	8¾ inches	None 1 inch increase	2¾ inches	Stump in pretty good condition.
Compound fracture of ankle joint and tarsus	Freder'ksburg, Va.	May 3, 1862	3 mos.	1 year & 2 mos.	10½ inch.	¾ inch	4¾ inches	Stump unsound, some ulceration and exfoliation, secondary.
Comp'd com. fract. of ankle joint .	Freder'ksburg, Va.	Dec. 13, 1862	8 mos.	1 year & 7 mos.	9½ inches	None	4½ inches	Some necrosis, small ulcers and thickening of periosteum, improving.
Comminuted fracture of lower half of leg	Ft. Wagner, S. C.	July 18, 1863	6 mos.	18 mos.	—	None	None	Stump flexed on thigh, badly ulcerated, will require knee support.
Comminuted fracture of middle of leg	Ft. Wagner, S. C.	July 18, 1863	5 mos.	7 mos.	Knee	support	—	Stump not healed, flexed at nearly right angles, partial anchylosis, very tender near crest.
Comp'd com. fract. of tarsus and calcaneus, ankle joint not injured	Ft. Wagner, S. C.	July 18, 1863	7 mos.	10 mos.	11½ inch.	¾ inch	3 inches	Stump mainly healed, well formed.
Compound fracture of tarsus .	Ft. Wagner, S. C.	July 11, 1863	7 mos.	1 year	8½ inches	1 inch	3 inches	Stump healed.
Comp'd com. fract. of lower third of leg	Ft. Smith, Arkansas	Aug. 28, 1864	1 year	1 year	4 inches	¾ inch	3 inches	Slight atr'phy, very good.
Foot while feet insensible and in an almost moribund state by fever, gangrene ensuing.	Hospital Point Rocks	Dec. 1864	9 mos.	9 mos.	5½ inches	¼ inch increase	3½ inches	Very good, not quite healed.
Destruction of foot at ankle joint .	Mobile, Ala.	April 1, 1865	3 mos.	5 mos.	11½ inch.	1 inch increase	1 inch	Much infiltrated, not healthy, much enlarged.
Comp'd com. fracture of upper middle of leg .	Averysboro, N. C.	M'ch 16, 1865	4 mos.	—	2½ inches	None	1½ inches	Bad posterior flap, pendulous, damaged by exfoliation.
Comp'd com. fracture middle third of leg	Freder'ksburg, Va.	May 3, 1863	7 mos.	9 mos.	4 inches	1 inch	2 inches	A prisoner 9 days, stump healed and vigorous.
Comp'und comminuted fracture of ankle joint . .	Freder'ksburg, Va.	Dec. 1, 1862	11 mos.	14 mos.	9½ inches	1 inch	5 inches	Stump not entirely healed, prognosis favorable.
Compound comminuted fracture of ankle joint .	Freder'ksburg, Va.	Dec. 17, 1862	1 year	15 mos.	10½ inch.	None	2 inches	Model stump, general health good.
Comp'd fracture of leg, lower middle	Bull Run, Va.	Sept. 1, 1862	11 mos.	1 year & 8 mos.	6 inches	¾ inch	4 inches	Stump flexed, not perfectly healed.
Comp'und fracture lower middle of leg	Bull Run, Va.	Aug. 31, 1862	19 mos.	21 mos.	—	None	None	Stump healed, flexed right angle, tendons rigid; good, clean knee support.
Comp'd com. fracture of the entire lower half of the leg	2d Bull Run, Va.	Aug. 29, 1862	16 mos.	18 mos.	4½ inches	1 inch	4 inches	Stump healthy.
Comp'und fract. of lower third of leg	Bull Run, Va.	Aug. 30, 1862	8 mos.	10 mos.	2½ inches	None	None	Stump ulcerated, not ready.
Comp'und comml. fract. lower and middle of thigh	Antietam, Md.	Sept. 17, 1862	11 mos.	14 mos.	5 inches	2½ inches	3½ inches	Stump well, cicatrices healthy.
Comp'und fracture knee joint and patella	Antietam, Md.	Sept. 17, 1862	11 mos.	22 mos.	10 inches	¼ inch	3½ inches	Necrosis of end of bone to be removed, stump s'und and smooth.

TABLE OF TWO HUNDRED AND EIGHTY-SEVEN CASES

Name.	Regiment.	Occupation.	Limb.	Point of Operation.	Method.	Where performed.	Length of Time after Injury.	Cause.
M. M.	9th N. Y. Vols.	Printer	L.	Lower third 1st amputation	Lateral flaps Syme's mode	—	1st, 24 hours 2d, seven months	Solid shot sloughing & want of care
M. H.	63d N. Y. Vols.	Laborer	L.	Lower and middle third	Posterior flap	On the field	Six days	Minie-ball
M. L.	Battery E, N. Y. A.	Clerk	R.	Lower and middle third	Circular	On the field	Six hours	Piece of shell
W. W.	8th Maine Vols.	Farmer	R.	Lower third	Lateral flaps	In field hospital	Twenty-fo'r hours	Piece of shell
J. B. G.	114th N. Y. Vols.	Captain	L.	Middle and upper third	Circular	On the field	Twenty-fo'r hours	Minie-ball
P. H.	46th N. Y. Vols.	Boiler-maker	L.	Upper third	Posterior flap	—	Twelve hours	Minie-ball
J. P. C.	115th N. Y. Vols.	Mason	L.	Middle third	Posterior flap	On the field	Two hours	Fragment of shell
J. M.	52d Penn.	Farmer	L.	Upper and middle third	Ant. post. flap	Stone Hospital, Washington, D. C.	Eight days	Rifle-ball
J. G. S.	7th N. H.	Farmer	R.	Lower third	Circular	In hospital	Three hours	Fragment of shell
W.H. R.	4th N. H.	Shoe-maker	L.	Lower third	Ant. post. flap	In field hospital	One hour	Explosion of torpedo
H. S.	8th N. Y. Cavalry	None	L.	Lower third	Ant. post. flap	In Lincoln Hosp., D. C.	Five weeks	Carbine-ball

OF RECOVERED AMPUTATION OF THE LEG.—(*Continued.*)

Description of Injury.	Battle.	Date.	Length of time from Amputation to Examination.	Length of time from Amputation to Application.	Length of Stump.	Atrophy.		Remarks, Generally made at Time of Application of Artificial Limb.
						Proximal Portion.	Distal Portion.	
Shattering the phalanges and metatarsal bones of foot	Antietam, Md.	Sept. 17, 1862	9 mos. 2d, 3 mos.	1 year 2d, 5 mos.	12½ inch.	1 inch	3 inches	Stump nearly healed.
Comp'd com. fract. of ankle joint	Antietam, Md.	Sept. 17, 1862	9 mos.	—	7¾ inches	3½ inches	3½ inches	Stump well cicatrized, neuralgia.
Injury of foot through tarsus	James River	Oct. 22, 1864	7 mos.	8 mos.	8½ inches	None	3 inches	Not entirely heal'd, four inches of necrosed fibula removed, March 12, 1865, June 14, healed.
Comp'd com. fracture of the tarsus and end of tibia	Jacksonville, Fla.	March 26, 1863	5 mos.	7 mos.	10¾ inch	1 inch	3 inches	Some necrosis, ulcers will recover soon, stump well healed, model shape, excess of length.
Comp'und commi. fract. lower third of leg	—	Sept. 10, 1864	5 mos.	7 mos.	5½ inches	¾ inch	2½ inches	Some atrophied, very good.
Comp'd com. fracture of low. third of leg	—	Aug. 1, 1864	5 mos.	7 mos.	4 inches	None	3½ inches	Good stump, flexed.
Comp'd com. fract. of foot and ankle	—	July 30, 1864	6 mos.	9 mos.	7½ inches	None	¾ inch	Very good.
Comp'und comminuted fracture of lower third of leg	Williamsburg, Va.	May 8, 1862	22 mos.	2 years & 1 month	5½ inches	¾ inch	2 inches	Stump healed, cicatrices extensive, owing to ulceration, fibula longest.
Destruction of leg at lower third .	On picket duty	Oct. 1, 1863	4 mos.	6 mos.	5 inches	1 inch	3 inches	Stump healed, posterior part pendulous.
Comp'd com. fracture of tibia, astragalus, articulation	On picket duty	Sept. 8, 1863	5 mos.	8 mos.	10 inches	1½ inches	4 inches	Stump healed, vigorous.
Comp'und fracture of tarsus . . .	Beverly Ford, Va.	June 9, 1863	8 mos.	11 mos.	8¾ inches	1 inch	3 inches	Stump healed, good.

I.

LIMB AMPUTATED.

Comparative frequency of amputation of right and left leg.

THE following table gives the frequency of amputation of the limb, whether right or left, in an aggregate of 445 cases of thigh and leg amputations: —

Limb.	Right.	Left.	Total.
Thigh	92	66	158
Leg	134	153	287
Totals	226	219	445

From this table it would appear that there is a difference in the liability of the two lower extremities to those accidents or injuries which necessitate amputation of the thigh or leg in military practice. In a gross number, comprising both thigh and leg amputations, this difference, though not very great, is in favor of the right limb. When, however, we separate the thigh from the leg amputations, we find this discrepancy becomes very marked in regard to both classes of cases. In the thigh amputations the right limb required removal in more than half of the total number of cases; while in the leg the left limb amputations considerably exceed the right.

Frequency of right and left leg amputations in the French army.

Nor is this peculiarity in the relation of thigh and leg amputations to the right and left side accidental; for, on referring to other collections of cases, the same difference is traceable. For example, in an aggregate of 484 amputations in the thigh and leg, collated by Chenu[1] from the records of French surgery in the Crimea, the following comparative results are deducible: —

Limb.	Right.	Left.	Total.
Thigh	73	61	134
Leg	169	181	350
Totals	242	242	484

In this table we have results strikingly similar to those which were obtained from the records of American military surgery. Of

[1] *Rapport au Conseil de Santé des Armées.*

the aggregate amputations in the lower extremity, the operation falls about equally on both limbs. But this result is found not to be due to an equality of amputations throughout the entire limbs, but to the fact that an excess of right thigh amputations is counterbalanced by an excess of left leg amputations in a given number of all amputations impartially collated. This result is not vitiated by the statement that the total number of leg amputations greatly exceeds that of the thigh amputations, for the same ratio holds true whether we diminish or increase the number of each.

II.

FREQUENCY OF AMPUTATION IN THE SEVERAL REGIONS OF THE THIGH AND LEG IN 439 RECOVERED CASES.

Comparative frequency of amputation in various regions of thigh and leg.

The comparative frequency of amputation in the various regions of the thigh and leg in a given number of recovered cases, is illustrated by the following table: —

Region.	Thigh.	Leg.
Upper third	15	103
Middle third	66	75
Lower third	74	106
Totals	155	284

In regard to thigh amputations, we should infer from this table either that a much less number of amputations are performed in the upper than in the middle third, and in the middle than in the lower third, or that the same number being performed in each division, the proportion of recoveries are largely increased as we pass from above downwards. Both of these inferences are true, as will appear from the following statistical table: —

Region.	British Army, in Crimea.		Confederate Army.		Sherman's Campaign. (Andrews.)	
	Rec'd.	Died.	Rec'd.	Died.	Rec'd.	Died.
Upper third	5	34	50	61	5	15
Middle third	26	39	87	87	13	16
Lower third	26	34	143	126	61	36
Totals	57	107	280	274	79	67
Grand totals	164		554		146	

This table sustains the inferences drawn from the preceding table, that while amputations in the upper third of the thigh are much less frequent than in either of the other divisions of the thigh, they are also largely more fatal. In the British army in the Crimea, the amputations in the upper third of the thigh were but 23.8 per cent. of the total thigh amputations, while the fatal cases of amputation in this region equal nearly one third of the total mortality of thigh amputations. In the Confederate service, the amputations in the upper third of the thigh were 20 per cent. of the total thigh amputations, and the mortality was 22.2 per cent. of the total mortality. In Sherman's campaign,[1] the amputations in the upper third were but 13.7 per cent of the thigh amputations, but the mortality was in nearly the same ratio to the total mortality as in the British and Confederate service, being 22.2 per cent.

Passing from the upper to the middle third, we find these statistics establish the fact that there is not only a larger gross number of amputations than in the upper third, but that there is a diminished rate of mortality. The fatal cases in the middle third do not greatly exceed the cases of recovery, being 46 per cent., while in the upper third the fatal cases are very largely in excess.

In regard to amputations in the lower third, these tables show that the number in general equals the total number in both of the other regions, with a still further reduction of the proportionate mortality, the successful considerably exceeding the fatal cases, except in the records of the British army.

Applying these facts to the first table, which consists of only recovered cases, and we may safely conclude that the 15 cases of recovery after amputation in the upper third represent a much larger number of fatal cases, and that the 66 amputations in the middle third represent about an equal number of fatal cases, while the 74 amputations in the lower third represent a less number of fatal cases, in the same regions respectively.

In regard to amputation of the leg, the above table gives the largest proportion of recoveries in the lower third, and the least in the middle third; the upper and lower third being nearly equal in numbers, while the middle third furnishes but a little more than one fourth the total number of cases. It is stated in the Surgeon-General's Report,[2] that the majority of cases of amputation of the

[1] *Statistics of Sherman's Campaigns*, by E. Andrews, M. D., p. 64.
[2] Circular No. 6.

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leg was in the upper and middle third. In that case this collection shows a partial selection, and most favorable to amputation in the lower third. If, however, we compare it with the following other group of cases in which both the fatal and successful cases are recorded, we shall find a confirmation of the above conclusions: —

FRENCH ARMY.[1]

Region.	Recovered.	Died.
Upper third	259	84
Middle third	14	3
Lower third	21	26

III.

NATURE OF MISSILES.

The following table comprises the various missiles with which the wounds were inflicted in 429 cases of amputation of the lower extremity: —

Missiles.

Missile.	Thigh.	Leg.
Minie-ball	58	84
Musket-ball	22	52
Rifle-ball	18	29
Shell	26	56
Grape-shot	10	20
Canister-shot	3	9
Solid shot	7	–
Gunshot	6	5
Torpedo	1	4
Pistol-shot	1	–
Cut with an axe	1	1
Fall of a tree	1	1
Injury by overturning of caisson	1	–
Cannon-ball	–	3
Railroad injury	–	5
Injured in a turret	–	1
Explosive ball	–	1
Burn	–	1
Fall	–	1
Rusty nail thrust into foot	–	1
Totals	155	274
Grand total	429	

Nearly two thirds of the injuries which required amputation of the lower extremities, in a total of 429 recovered cases, were

[1] Legouest.

inflicted by the missiles of the infantry, namely, the minie, musket, and rifle balls. Of these, the minie-ball was used much more frequently than both the musket and rifle balls, or was much more destructive, the proportion being, minie-balls 142, musket and rifle balls 121. The difference between the recovered cases of amputation after injuries inflicted upon the thigh and leg by these various missiles is considerable. In the thigh the amputations for injuries inflicted by the minie-ball are 58, and by the musket and rifle balls 40; while in the leg the minie-ball injuries are 84, and by the musket and rifle balls 81.

Recovery from amputations after injuries inflicted by shell are more frequent in the leg than in the thigh, in the following proportion: recovered thigh amputations about one sixth, and recovered leg amputations more than one fifth, of the total number of thigh amputations. It is noticeable that the solid shot gives a number of recovered amputations of the thigh and none of the leg, while the torpedo furnishes more recovered cases of leg amputation than of the thigh.

We may compare the nature of the missiles with which severe wounds of the lower extremities were inflicted, as appears in the above table and in the records of the Crimean War: —

NATURE OF THE MISSILES WITH WHICH THE WOUNDS WERE INFLICTED IN 466 RECOVERED AMPUTATIONS OF THE LOWER EXTREMITY, IN THE FRENCH ARMY IN THE CRIMEA.

Limb.	Ball.	Boulet.	Éclats de Projectiles Biscaien.
Thigh	26	18	86
Leg	109	35	192
Totals	135	53	278

Missiles which inflicted wounds requiring amputation of thigh and leg in French army in Crimea.

It is apparent from this table that in the Crimean campaign, which partook of the nature of a siege, the most destructive wounds were inflicted by artillery.

Both tables show a preponderance of recovered leg amputations in about the same proportion.

IV.

NATURE AND LOCATION OF THE INJURIES BY VARIOUS MISSILES IN 422 RECOVERED CASES OF AMPUTATION OF THE LOWER EXTREMITY.

	Thigh.						Leg.					
	Fractures.			Wounds.			Fractures.			Wounds.		
	Thigh.	Knee.	Leg.	Thigh.	Knee.	Leg.	Leg.	Ankle.	Foot.	Leg.	Ankle.	Foot.
Minie-ball	24	23	5	–	2	–	49	25	9	2	–	–
Musket-ball	9	7	1	1	2	1	25	17	7	1	1	–
Rifle-ball	7	7	–	–	2	1	18	7	3	1	–	–
Shell	1	14	6	1	–	4	34	15	7	–	–	–
Grape-shot	3	6	2	–	–	–	11	7	2	–	–	–
Canister-shot	2	1	–	–	–	–	8	1	–	–	–	–
Solid-shot	1	3	1	–	–	–	6	1	3	–	–	–
Gunshot	–	3	1	–	–	–	4	1	–	–	–	–
Torpedo	–	1	–	–	–	–	2	2	–	–	–	–
Railroad injury	–	–	–	–	–	–	3	1	–	–	–	–
Cannon-ball	–	–	–	–	–	–	2	–	1	–	–	–
Cut by axe	–	–	–	–	–	–	–	–	–	1	–	–
Fall of tree	–	–	–	–	–	–	–	1	–	–	–	–
Injured in turret	–	–	–	–	–	–	–	–	1	–	–	–
Explosive ball	–	–	–	–	–	–	1	–	–	–	–	–
Burn	–	–	–	–	–	–	–	–	–	–	–	1
Fall	–	–	–	–	–	–	1	–	–	–	–	–
Nail, wound by	–	–	–	–	–	–	–	–	–	1	–	–
Totals	47	65	16	2	6	6	164	78	33	6	1	1

Thigh amputation for fractures	128	Thigh amputation for wounds	14
Leg amputation for fractures	275	Leg amputation for wounds	8
Total	403	Total	22

From the preceding table it appears that amputations for fractures are more frequent, in a given number of recovered cases, than for wounds, in the proportion of 18 to 1. And this difference is found, on inquiry, to be far the greatest in the leg. In the thigh the amputations for fractures are to amputations for wounds in the ratio of about 8 to 1, while in the leg amputations the ratio of fractures to wounds is as 34 to 1.

Proportion of amputations for wounds and fractures.

The location of fractures is found in the amputations of the thigh, in largest number involving the knee, and in amputations of the leg, involving the bones of the leg. The

Location of fractures.

largest number of fractures into the knee were produced by the minie-ball, and the next largest by shell. The fractures of the leg necessitating amputation were produced in largest numbers by the minie-ball, and next in frequency is the shell. Injury to the ankle joint was not as frequently the cause of amputation of the leg, in proportion to the total amputations of the leg, as injury to the knee the cause of thigh amputations in proportion to the entire number of amputations in that part. Fractures of the leg were followed by comparatively few amputations of the thigh, being in the ratio of eight amputations for fractures in the knee and thigh to one of the leg. Nearly the same ratio obtains between amputations of the leg for fractures involving the foot, and amputations for fractures of the ankle and leg.

Comparative table from French statistics.

The following table, compiled from Chenu,[1] affords a comparison between the above collection and the French statistics of the army in the Crimea, as to the frequency of amputation of the thigh and leg for fractures in certain regions in recovered cases: —

Region.	AMPUTATION OF	
	Thigh.	Leg.
Fracture of femur	48	–
Destruction of thigh or leg	13	–
Fracture of knee	24	–
Fracture of leg	43	196
Fracture of foot	1	57
Destruction of leg	–	29
Totals	129	282

This table presents a striking contrast with the preceding, so far as relates to thigh amputations. In the former, compound fracture of the knee was the form of injury necessitating amputation in nearly half the recovered cases, while in the latter this injury occurred in but about one fifth of the total cases. We are not able to determine to what this discrepancy is to be attributed, as we are not able to give the mortality in the Federal army; but it is probable that there was a much greater mortality among the French, as the percentage of fatal cases in amputations for this injury was thirty-seven.

[1] *Rapport au Conseil de Santé des Armées.*

V.

DISTRIBUTION OF INJURIES REQUIRING AMPUTATION OF THE LOWER EXTREMITY IN RECOVERED CASES.

(*a*) *One hundred and forty-one Amputations of Thigh.*

Compound fracture of femur	10
Compound fracture of middle third	7
Compound fracture of lower third	27
Simple fracture of femur	1
Compound fracture of knee	59
Compound fracture of knee and upper third of leg	12
Destruction of leg	6
Compound fracture of leg — upper third	3
Compound fracture of leg — middle third	5
Compound fracture of leg — lower third	9
Destruction of ankle	2
Fracture	1
Wound of thigh	2
Wound of knee	5
Wound of leg	1
Wound of popliteal artery	1
Gangrene of toe	1
Total	141

(*b*) *Two hundred and eighty-seven Amputations of Leg.*

Comminuted fracture of the upper third	3
Comminuted fracture of the middle third	67
Comminuted fracture of the lower third	75
Comminuted fracture of the ankle joint	57
Fracture involving the ankle joint	2
Destruction of leg	20
Destruction of ankle joint	14
Destruction of foot	8
Destruction of calcaneum	1
Compound fracture of calcaneum	1
Wound of posterior tibial artery	11
Wound of soft parts of leg	11
Gangrene following a burn	1
Injury of tibia without fracture	1
Injury of knee and patella	1
Injury of knee (?)	11
Total	287

Injuries requiring Amputation of the Thigh. — Of the injuries of the thigh requiring amputation, in a given number of recovered cases, compound fracture of the lower third is by far the most frequent; comprising nearly two thirds of all the cases. We have already alluded to the proof that a less number of amputations are performed in the middle and upper third of the thigh, and that they are more fatal in these regions. This fact will account in part for the great discrepancy which this table shows between the total recovered amputations in these different regions.

The injury which necessitates the largest number of amputations of the thigh is seen to be compound fracture of the knee. The total number of these injuries, including those which involve also the upper third of the leg, comprises about one half of all the causes of amputation of the thigh. This subject is deserving of a more critical examination.

At the period of making his Report,[1] the Surgeon-General states that 1,183 cases of gunshot wounds of the knee joint, with or without fracture of the patella, or of the epiphyses of the femur or tibia, had been recorded. Of these, 770 had terminated, and the results were known. The following statement of the treatment and its results, so far as ascertained, is given in the 1,183 cases of knee-joint injury reported: —

Treatment.	No. of Cases.	Recovered.	Died.	Undetermined.
Amputation	718	121	331	266
Excision	11	1	9	1
Conservative measures	454	50	258	146
Totals . . .	1,183	172	598	413

It would appear from these facts that in a little less than two thirds of the wounds of the knee joint amputation was resorted to, and a mortality of 73.23 per cent. occurred in the determined cases. In the 11 cases submitted to exsection the mortality was 90 per cent. In a little more than one third of the total cases, conservative measures were adopted, with a mortality in the terminated cases of 83.76 per cent.

We may safely conclude that in this collection of cases amputation was resorted to in the severest form of injuries, as when the joint was freely opened, with or without fractures of the extremities of bones entering into the joint; while conservative measures were adopted in slighter forms of injury, and when there was

[1] Circular No. 6.

doubt whether the cavity of the joint was involved. And this opinion is confirmed by the Surgeon-General, who states that, "with six or eight exceptions, the fifty recoveries without amputation, classified with gunshot wounds of the knee joint, were examples of fracture of the patella, in which the evidence that the joint was opened was not unequivocal."

It is evident, therefore, that amputation was the acknowledged method of treatment in severe gunshot injuries of the knee joint, during the war. And the comparative results of this treatment justify the rule now so firmly established in military surgery. The mortality was ten per cent. less than when conservative measures were employed, and nearly twenty per cent. more favorable than excision. If we take into consideration the remark of the Surgeon-General that all the successful cases treated conservatively, except six or eight, were so slight as to be of a doubtful character, the comparative results of amputation in grave injuries of the knee joint are far more favorable.

Professor Chisholm, of the Medical College of South Carolina, a surgeon to the insurgent forces, gives statistics[1] of the conservative treatment of gunshot wounds of the knee joint which are altogether more favorable than those compiled by the Surgeon-General. Of 103 cases treated, 50 recovered, and 53 died; the mortality per cent. being but 52.

In answer to the objection that many of these cases must have been of a trivial character, and could not have implicated the cavity of the articulation, he refers to the duration of treatment in the successful cases, which gives an average of 166 days, in proof of the severity of the wounds. The shortest period of treatment was 96 days. He concludes, therefore, that they were cases of the perforation of the joint by balls without the crushing of bones being detected.

This comparison does not invalidate the general conclusion that amputation of the thigh should be the rule of practice in severe gunshot injuries of the knee.

The following tables are instructive, as they illustrate the condition of stump in an amputation at different points of the thigh after gunshot wounds of the knee joint.

[1] *Medical Times and Gazette.* London, December 29, 1866.

THIRTY-THREE CASES OF RECOVERED AMPUTATIONS OF THE THIGH IN THE LOWER THIRD, FOR GUNSHOT INJURIES OF THE KNEE JOINT.

Missile.	No.	Method.	No.	Result.		
				Good.	Imperfect.	Unknown.
Minie, rifle, and musket ball . .	25	Flap	19	16	1	2
		Circular	6	6	–	–
Cannon-ball, shell, grape, torpedo	8	Flap	7	5	1	1
		Circular	1	1	–	–

In these 33 cases it will be observed that amputation was successfully performed in the lower third of the thigh in 8 cases of wound of the knee joint by shells, by cannon-ball, by grape-shot, and by torpedo. These were doubtless very grave forms of injury, and attended with more or less destruction of the soft parts. In some instances it is noticed that the limb was nearly severed at the knee. The fact that they still admitted of successful amputation at a point so near the seat of injury is instructive, as it proves that in the severest gunshot wounds of the knee we may still select the most favorable point in the thigh for amputation with a fair prospect of success.

Another fact is noticed, namely, that in all of these cases of amputation for wounds of the knee by shell and solid shot but one, the flap method was preferred. This is the more remarkable as the circular method is generally considered especially adapted to the lower third of the thigh, and to wounds attended with great destruction of the soft parts.

Of these 33 cases, 26 were performed by the flap, and 7 by the circular methods. The results of these cases are more favorable to the circular method, all of which gave good stumps.

TWENTY-NINE CASES OF RECOVERED AMPUTATIONS AT THE JUNCTION OF THE MIDDLE AND LOWER THIRD OF THIGH.

Missile.	No.	Method.	No.	Result.			
				Good.	Imperfect.	Very poor.	Unknown.
Musket, minie, and rifle ball	20	Flap	9	5	2	1	1
		Circular	11	5	6	–	–
Shell, solid, and grape shot	9	Flap	8	4	3	1	–
		Circular	1	1	–	–	–

In this table we have a larger proportion of cases of wounds

by shells, solid, and grape shot. The ratio of these missiles to the musket, rifle, and minie balls is nearly that of one third. From this it appears that as a rule surgeons amputate higher than the lower third in wounds of the knee joint by these destructive missiles.

But the most interesting feature of this table is the comparatively large proportion of circular operations, and the comparatively unfavorable results of this method, when practiced at the junction of the middle and lower third of thigh after knee-joint injuries. Of the 12 circular amputations, 6, or one half, gave imperfect stumps, while of the flap operations 9, or more than one half, gave good results. The difference between the results in this and the preceding table is striking: in the former the final results of all the amputations were very favorable, and especially of the circular method; in the present table both methods failed of giving generally good results, the circular being the most unsuccessful.

NINETEEN CASES OF RECOVERED AMPUTATIONS AT THE MIDDLE THIRD OF THIGH.

Missile.	No.	Method.	No.	Result.			
				Good.	Imperfect.	Very poor.	Unknown.
Minie, musket, and rifle ball	10	Flap	6	3	1	–	2
		Circular	4	3	1	–	–
Shell, grape, canister, cannon, and solid shot . .	9	Flap	8	7	–	1	–

In this table we find a still greater proportion of injuries of the knee joint by the larger form of missiles; 9 of the 19 cases being injuries by shells and solid shots. We have here still further evidence of the destructive character of the wounds of the knee which called for amputation, and the necessity which frequently existed of amputating at a distance from the wounds.

We have noticed in the preceding tables that amputations in the lower third of the thigh gave good results, while those performed at the junction of the middle and lower third gave much more unfavorable results. In the middle third we find the table reversed, and both forms of amputation are again highly successful as regards the final results.

The proportion of circular to flap amputations is about the same as in the first table.

FIVE CASES OF AMPUTATION AT THE JUNCTION OF THE UPPER AND MIDDLE THIRD OF THE THIGH.

Missile.	No.	Method.	No.	Result.		
				Good.	Imperfect.	Very poor.
Shell and grape shot	3	Flap	–	–	–	–
		Circular	3	2	1	–
Musket-ball	2	Flap	–	–	–	–
		Circular	2	1	–	1

FOUR CASES OF AMPUTATION IN THE UPPER THIRD OF THIGH.

Missile.	No.	Method.	No.	Result.		
				Good.	Imperfect.	Very poor.
Solid and grape shot, and shell .	3	Flap	2	–	1	1
		Circular	1	1	–	–
Minie-ball	1	Flap	–	–	–	–
		Circular	1	1	–	–

In amputation at the junction of the middle and upper third of the thigh the larger number of wounds were inflicted with solid shot. It is remarkable that in every case the circular operation was performed in preference to the flap method. The result, however, was not favorable in the majority of cases.

Of the four amputations in the upper third, but one was performed for wound by a minie-ball. From this fact we infer that, in general, wounds of the knee joint by a rifle-ball admit of amputation in the lower part of the thigh, and rarely necessitate the removal of the limb high up. It is also apparent that in a given number of cases of amputation in the upper third of the thigh for gunshot wound of the knee, a large majority will be necessitated by the larger and more destructive missiles. The results of the two methods prove the value of the circular method.

From these tables it would appear that in a total number of cases of recovery after amputation of the thigh, for gunshot injury of the knee joint, the operation was performed in the lower third in more than one third of the cases; at the junction of the middle and lower third in a little less than one third of the cases; in the middle third in about one fifth of the cases; and above this point in

a little less than one thirteenth of the cases. The total amputations at and below the junction of the middle and the lower third of the thigh comprise more than two thirds of all the cases.

It is evident, then, that in gunshot injuries of the knee joint successful amputation is far more frequently performed below than above the middle of the thigh. The comparative mortality of this operation, according to the Surgeon-General, was very small. Of 243 amputations in the lower third of the thigh for wounds of the knee, 112 died, being a mortality of 46 per cent.[1] The Confederate army reports give the following statistics of this operation: total number of amputations in the lower third of the thigh for wounds of the knee, 269, of which 126 died, being a mortality of 46 per cent.[2] We have here a striking coincidence in the success of a given operation for the same cause.

It would be interesting to note also the comparative mortality of amputation at other points in the thigh for these wounds, but we have not the data.

Period of amputation.

The period at which the operation was performed after the injury, in the majority of cases, proves not only the severity of the wound, but the importance of early amputation to insure a successful result. In more than one third of the cases the operation was performed within six hours of the injury, and in nearly one fourth of the cases it occurred between the 6th and 24th hour. In other words, within twenty-four hours of the injury about two thirds of the operations were performed. It should also be noticed that 67 or more than two thirds of the operations were performed on the field. These facts prove both the severity of the original injury, and the necessity of an early operation; for it must be remembered that this is a record of successful cases.

Nature of the injury.

If there were any doubt as to the severity of the wounds which led to amputation in these cases, it would be dispelled by a reference to the record of the nature of the injuries. In all but 13 cases there existed a fracture, generally comminuted; in the remaining cases the joint was freely opened, and the leg nearly dissevered at this point.

Missiles.

Of the missiles with which the wounds were inflicted, in 59 cases the minie, rifle, or musket ball was employed; in 17 it was a fragment of a shell; in 13 it was a solid shot. It follows that the wound must, in one third of the cases, have been of the severest character.

[1] Report of the Surgeon-General (Circular No. 6.)

[2] Chisholm, *London Medical Times and Gazette*, December 29, 1865.

The following opinions of surgeons sustain the conclusions drawn from the preceding statistics, and are worthy of record in this connection.

Professor A. C. Post gives the result of his observations in regard to gunshot wounds of the knee joint as follows: —

"Gunshot wounds penetrating the knee joint are generally fatal, unless the limb be amputated. This is especially the case when, in addition to the wound of the joint, there is extensive fracture of the articular extremity of the femur or tibia.

"The practical rule which I would recommend in gunshot wounds of the knee is this, to amputate in all cases where the ball has passed through the centre of the joint, or where the inferior articular extremity of the femur or the superior articular extremity of the tibia has been fractured, but to make an attempt to save the limb where the ball has not penetrated deeply into the joint, and when the patella only has been fractured. In the class of cases in which I have recommended an attempt to save the limb, the attempt will always be attended with some danger to the life of the patient."

Surgeon George A. Collamore, 100th Ohio Vols., speaks of the causes of thigh amputation as follows: —

"In gunshot fractures of the femur, amputation will depend on the location of the injury. If the fracture occur in the upper third, I should prefer to trust the case to nature, with such aid from position, splints, etc., as could be obtained. In fractures affecting the lower two thirds of the limb, I should amputate so as to remove the fractured portion. Gunshot wounds involving the knee joint invariably demand amputation, if possible, just above the condyles and below the medullary canal. Gunshot fractures of the tibia, involving much comminution and laceration of the muscles, usually require amputation. It would be a very unusual case that I would attempt to preserve. In my opinion conservative surgery should not be carried too far in gunshot fractures of the lower extremities, admitting amputation. Extensive fractures of the tarsal bones, involving the malleoli or articulation, require amputation at the ankle. Fractures of the fibula do not usually require amputation, as this bone is but slightly instrumental in the support of the body."

Professor Paul F. Eve, of the Confederate service, makes the following communication in regard to the success of amputation of the thigh during the war, as compared with the same operation in former wars: —

"Ribes examined four thousand veteran soldiers in the Hotel des Invalides in Paris, and found not one who had undergone amputation of the thigh, or who had sustained an injury of the femur by a shot. Pro-

fessor Malgaigne of Paris, with whom I was associated in the war, makes the same report of all similarly wounded during the Polish campaigns of 1831. At the close of the Mexican War in 1847, Dr. McSherry of the United States navy, on detached duty, was permitted to accompany General Scott's army, and declared that, although he remained in the city of Mexico eight months after the battles, and walked the hospitals, he did not see one soldier restored to health after a gunshot wound of the thigh, involving its fracture. Of an almost similar import were my communications to the Nashville *Journal of Med. and Surg.*, after the late Italian campaign. Writing from Turin, July, 1859, it was stated that while the results were good after injuries in the upper extremities, the reverse was true of those involving the inferior, with or without amputation, whenever a compound fracture existed. Dr. Salleron, chief surgeon of the military hospital of that city, assures me that the nearest he came to saving a patient thus wounded, was a Zouave shot in the Crimea, who remained seven months in a hospital at Constantinople before attempting to return to France, and when he did so, finally died of pyæmia. In Milan I took notes of five cases of compound fractured thighs, which were all I saw there, fifty-six days after being wounded: in three there was little or no hope of recovery; another had had the limb amputated above the knee, and was doing well; while the fifth was the only one expected to recover with the limb.

"In amputations of the thigh in the Crimean War, sixty-four in every one hundred died; in the Paris hospitals seventy-five per cent., and in the Polish and Mexican wars one hundred per cent., or every one operated on, died. Of twenty-one disarticulations at the hip-joint, every one was fatal, and eighty-six per cent., according to McLeod, of amputations in the upper third of the thigh died. As late as 1861, Mr. Thomas Bryant, surgeon to Guy's Hospital, one of the best appointed and managed of these institutions in London, reported seventeen cases of thighs requiring treatment. Ten were amputated, seven of them died; seven were attempted to be saved, four died; thus, of the seventeen cases eleven died. The most favorable return ever made, is that of Jules Roux, naval surgeon at Toulon, who saved four of six he amputated at the hip-joint; being by far the best success ever obtained by any one, though the circumstances were very propitious under which he operated. He mentions having seen twelve of these dreadful disarticulations; seven died. He also states that there were twenty-one cases of consolidated fractures of the thigh passing through his hospital from Italy. As Toulon was the only door through which the maimed could reach home (for Marseilles is a commercial and not a military port), it is highly probable that of all the two hundred and fifty thousand men who went to aid the Sardinians, these twenty-one constituted the whole number of all those wounded through the thigh bone who once more returned to la belle France with two legs.

"In the late terrible civil war our profession has nobly performed her duty, and America has reason to honor her surgeons. With pride and gratulation we point to the hundreds and thousands saved by their skill, even in compound fractures of the femur. Lieutenant-General Ewell survives an amputation through the upper third of the thigh; and so does Lieutenant-General Hood, performed by Professor Richardson of New Orleans, on the battle-field of Chicamauga. They so fully recovered, as is well known, that subsequently each commanded army corps in person on the field. I have seen as many as three soldiers conversing together in the streets of Augusta, Ga., each having lost a limb above the knee. I think I had two successful amputations of the thigh in Atlanta, and about the same number left under treatment in Columbus, Miss. I regret not having access to my official reports, but there must have passed under my supervision over one hundred of these amputations during two years and a half of hospital service. It is right, however, to say here that the majority of these were fatal.

"Primary amputations did decidedly best, and, if not before, this question ought now to be considered definitely settled. The majority of those who recovered after injury of the femur were operated on in the field, or before inflammation and its results had ensued. To this rule we have the single exception in those requiring disarticulation at the hip-joint. In these cases it is now ascertained that few constitutions can bear in quick succession such shocks as, first, the injury requiring this operation, and then, secondly, that produced by its performance. The statistics of McLeod in the Crimean War already referred to, giving twenty-one primary operations, followed by twenty-one deaths, contrasted with Roux's four successful out of six consecutive, or secondary amputations is determinate on this point."

Injuries requiring Amputation of the Leg. — The largest percentage of recoveries after amputation of the leg, occur from injuries in the lower third, and in this respect resemble the recoveries after amputation of the thigh. It is interesting to notice three recoveries after amputation of the leg for compound fractures in the upper third, the amputation being in the immediate vicinity of the injury. Amputation for compound fracture of the middle third gives also a large percentage of recovered cases. Injuries of the ankle joint led to amputation of the leg in about one fourth of the total cases. Injuries of the foot would seem to have been very rarely followed by amputation of the leg, but in the French army in the Crimea it was a frequent operation, there being fifty-seven amputations of the leg for wounds of the foot in a total of two hundred and twenty-five amputations of the leg, or about one fourth.

VI.

METHODS OF OPERATION, AND THE FREQUENCY WITH WHICH THEY WERE PERFORMED IN THE THIGH AND LEG.

The following table comprises the various methods of amputation in the thigh and leg, and shows how frequently they were performed in each division of the extremity: — Methods of amputation.

Methods.	Thigh.	Leg.
Circular	54	115
Antero-posterior flaps	78	93
Posterior flap	–	45
Anterior flap	10	2
Lateral flaps	6	21
Rectangular flap	5	–
Skin flaps and circular of muscles	2	8
	155	284

It is apparent that the amputations of the thigh and leg were performed either by the circular method or by some modification of the flap. Of the flap operations that which was generally preferred was the antero-posterior flap; the anterior, posterior, and lateral flaps being but seldom performed, with the exception perhaps of the posterior flap in the leg.

Of the two principal methods, the circular and antero-posterior flap, we notice that the antero-posterior flap was preferred more frequently in the thigh, and the circular in the leg. In the thigh the antero-posterior flap method comprises half the operations, while the circular exceed but little one third. In the leg these methods are nearly reversed, the circular amputations amounting to nearly three sevenths, and the antero-posterior amputations to but about one third. Antero-posterior flaps most frequent in the thigh, and circular in the leg.

Of the remaining methods the anterior, posterior, and lateral flaps have long been occasionally practiced, but without any definite results. The rectangular flap of Teale seems to have been performed in a few instances in the thigh. Other methods.

The method by flaps of skin and circular of muscles was performed in ten cases, two in the thigh and eight in the leg. This method seems to have become very popular with many military surgeons, especially with those who were compelled to transport their patients long distances. The surgeons in General Sherman's army came to prefer this operation to all Flaps of skin and circular of muscles.

others. Their method of operating was to make lateral flaps of the skin and a circular incision of the muscles; the lateral flaps brought in apposition gave a cicatrix running vertically on the face of the stump. In dressing the stump the ligatures were all brought out at the lower angle of the wound, and the drainage was perfect, leaving the upper portions of the wound dry. According to the testimony of many surgeons who had great experience in the transportation of the recently amputated, these stumps required dressing much less frequently than other forms, and union by first intention throughout three fourths of the wound was an almost constant result. In some cases it is stated that the stumps would remain so dry that the dressings would not require renewal in four or five days.

TESTIMONY OF SURGEONS AS TO THE VALUE OF DIFFERENT METHODS OF AMPUTATION.

Testimony of surgeons as to value of different methods.

The various opinions of surgeons in regard to the special merits of the different methods may be gathered from the following extracts.

Assistant-Surgeon Powers, U. S. Army, says: —

"If the patient is obliged to be removed soon after amputation, I prefer the circular operation, as the parts are steadier, and keep their place better; otherwise I generally use the flap operation."

Assistant-Surgeon Powers.

Assistant-Surgeon N. A. Meacher says: —

"I saw a great deal of trouble with stumps, on account of the flesh sloughing and leaving the end of the bone protruding, and I think the circular operation more liable to that trouble than the 'Liston flap,' which I prefer, unless it is in operating near the wrist or ankle."

Assistant-Surgeon Meacher.

Surgeon C. E. Deming, 28th Ohio Vols., prefers the flap only in certain locations, as follows: —

"In amputations of the arm, angle, and upper two thirds of the leg, I prefer the flap operation to the circular. The preference I have for the flap over the other is on several accounts; a more perfect covering is secured for the bone; the integument is only disturbed in the line of the incision, while in the circular the muscles are rarely ever cut close up to the retracted integument; the flap has less cutting and is speedier done, and the size of the flap can always be proportionably estimated to the size of the limb; in the circular it is

Surgeon Deming.

more or less guess-work. In the circular again the second cut is never exactly close up to the retracted skin; the third cut more or less haggles or cuts off the ends of the divided muscles of the second cut; the skin when brought over the end of the bone more or less gaps, and the cut ends of the muscles double in over the sawed end of the bone. It suppurates more and is usually longer in healing than the flap.

"At the lower third of the leg the circular is the best."

Surgeon P. H. Bailhache, 14th Illinois Cav., says: —

"In amputations I prefer the double flap (posterior and anterior) for the arm and thigh, and the 'combination' or 'semi-lunar and flap' for the leg and fore-arm. I am of opinion that the 'circular' amputation injures the integuments by frequent lesion of its nutritious vessels, which is done while dissecting it back upon itself — hence the flabby, waxy appearance of the parts in many instances. Some hold that there is less discharge of pus from a circular than from a flap operation; this may or may not be so; but even were such the case there is no advantage gained, as the drain upon the system is no greater, and the union of the flap is as speedy and as perfect. It is also said there is danger of transfixing or splitting the blood-vessels or nerves; this is mere theory, not substantiated by facts or experience, besides which ordinary care and a knowledge of the parts obviates the risk of doing so. Again, in the circular operation it is almost always necessary to split the integuments on one or both sides before they can be turned back and dissected sufficiently high to prevent the bone from protruding; so it is eventually 'two flaps' without the advantage of 'time' and at the expense of more or less injury to the integuments; if the muscles are not required as a cushion for the bone they can be readily cut out afterward without destroying the areolar structure," etc.

Surgeon Bailhache.

Surgeon George A. Collamore, 100th Ohio Vols., expresses nearly the same opinion. Although he formerly employed the circular method, he now prefers the flap, believing that it "allows more perfect approximation of the surfaces, and union by the first intention sometimes will take place, but never, so far as I have known, in the circular operation."

Surgeon Collamore.

Surgeon E. Batwell, 14th Michigan Vols., draws the following distinctions between the flap and circular: —

"From close observation, I am unable to give preference to either as far as regards healing, both depending on the constitution of your patient, and both healing with equal facility. Hemorrhage took place more frequently in circular operations, owing doubtless to vessels of large size retracting more readily when divided *straight across*, than those cut slanting, as in flap amputation. As soon

Surgeon Batwell.

as full reaction set in, these vessels poured out blood, and very frequently necessitated the opening of the stump to secure the bleeding artery. Anterior and posterior flaps healed more kindly than lateral ones, notwithstanding the latter possessed less tendency to accumulation of pus, and the sutures held the lips of the flaps together better; but the nervous twitchings of the stump made the bone protrude through the edges of lateral flaps more readily, and tore the newly organized plastic lymph. Any modifications of the above operations, or a combination of both, healed slowly and unsatisfactorily, invariably leaving painful stumps. Short anterior, with long posterior flaps made the process of healing very tedious, always leaving so painful a stump that a secondary amputation became necessary; I have thought that the nerve got under the bone, and was thus pressed on. The above observations were made from a similar number of flap and circular operations, with a view of deciding in my own mind the relative merits of each. I have measured the exposed surface, and was much astonished to find a *larger* extent on a circular than on a flap. In making the second sweep with the Catlin, I found that by inclining the edge of the knife towards the patient's body, so as to have the bottom of the incision an inch and a half or two inches higher up than the external, forming a hollow cone, a far nicer looking stump was formed, and one far better adapted for an artificial limb."

Surgeon W. Manfred, 22d Kentucky Vols., is of opinion that the flap method is more successful than the circular: —

Surgeon Manfred.

"I generally prefer the flap to the circular operation; it makes a better stump, and there is less waste of muscle in making the flaps, except in certain exceptional cases, when the circular operation is probably the best, as when the muscle is very thick, or when it is injured by the ball so as to make the flap operation inadmissible. Moreover, my flap cases have been uniformly more successful than the circular."

Surgeon B. T. Kneeland, — New York Cav., says: —

Surgeon Kneeland.

"I prefer flap amputations always, which have the advantage of saving time both in the operation and in the recovery, and as giving better results in every respect."

Surgeon H. C. Robbins, 101st Illinois Inf., says: —

Surgeon Robbins.

"I prefer flap operations in the arm and thighs as more likely to cover the bones and afford a soft cushion for an artificial limb. In the fore-arm and leg I would use the circular operation for similar reasons."

Surgeon N. Field, 66th Maryland Vols., says: —

"I prefer the flap method, because, as I believe, it makes a better covering for the end of the bone. The circular requires care to prevent trouble afterwards." Surgeon Field.

Surgeon J. C. Walton, 21st Kentucky Vols., prefers the flap, but believes that if the patient is transported any considerable distance there is danger that the flaps will separate: —

"I have generally performed the 'flap' operation, except in cases where there was much loss of the soft parts, or much contusion. It is most conveniently performed, and in healthy subjects frequently heals more rapidly. It makes a better covering for the stump, and a softer cushion for an artificial limb. The only objection to this method is that it gives more *suppurating surface*, — provided the patients are kept quiet, and are not required to be moved from place to place; but should the case require transportation several miles over rough roads the flaps are apt to gap open." Surgeon Walton.

Surgeon Chaddock, 7th Michigan Vols., says: —

"I prefer the flap; it gives greater mechanical neatness, less exposure of wound to air, and the chances of healing by first intention. I am also satisfied that the cut surface is less with the flap mode of operating, if well made, than it is in the circular." Surgeon Chaddock.

Surgeon ——, —— ——, says: —

"In the arm and thigh I invariably performed the flap operation; making in all cases where practicable antero-posterior flaps. My reasons for this method are several: 1st. The operation is more easily and quickly performed. 2d. The flaps are not so liable to slough as when they are made by the circular method. In the latter the skin and areolar tissue are dissected up to the extent of from two to four inches, cutting off, to a certain degree, their supply of blood; hence lowering their vitality, and making them more liable to slough. In the former, the skin and cellular tissue retain their connections with the more deep-seated tissues, and their vascular supply is not interfered with. 3d. In the flap operation the stump heals more quickly and with less suppuration, because the parts are brought more perfectly in apposition than they can be when the circular method is used. 4th. Because (and this follows as a corollary from the two preceding reasons) the flap method is less liable to be followed by pyæmia, erysipelas, or gangrene. 5th. Because this method gives stumps better adapted to artificial limbs than the other method: the end of the bone is more thickly covered. Surgeon ——.

"These reasons, which I think will be found to be good ones, certainly show the immeasurable superiority of the flap over the circular method. Even in the fore-arm and leg, I consider the flap the better operation."

Surgeon ——, —— ——, writes: —

Surgeon —

"I prefer the flap in large thighs, because I can judge more nearly the exact amount of covering I will have on the end of the bone, and that there will be less likelihood of sloughing and of protrusion of the bone. There will usually be a better covering for the bone than after circular operations, and the skin will not be so extensively detached from its normal relations to the muscular tissues, and it will not become so pale and so liable to ulcerate and slough where the edges come together over the bone. I believe that in gunshot wounds, particularly of the femur, the operation should generally be made by cutting from without, *i. e.* the antero-posterior, or lateral flaps, as the case may permit, should be made of proper size and shape, and with even edges through the skin and areolar tissue down to the muscles, either with a large scalpel or with the point of an amputating knife, and then the muscular portions of the thigh be quickly and freely divided down to the point where the femur is to be divided. In this way the flaps will be evenly made, the detached pieces of bone will not be caught upon the edge of your knife, as is so very often the case in transfixion, the flaps will come in exact coaptation, and the stump will be of the proper size and shape, and will have every inducement to partially adhere by primary adhesion. I look upon this plan of operating, in the army particularly, as worthy of attention, and can recommend it as having come into favor with those whom I have known to perform it. I have operated in this manner occasionally during the last two years."

Surgeon J. W. Williams prefers a covering without any muscle, and to secure this end he dissects off all muscle from the flap. He says: —

Surgeon Williams.

"I think it is new, and better than the common flap method. In the common antero-posterior flap operation in the lower third, the anterior flap is narrow, not equal to its fellow, and in consequence of the constant tendency of the thigh to evert, the end of the bone is apt to protrude at the inner angle of the narrow flap. And further, I have found that where the flaps were well relieved of muscle, the healing process was more rapid and kind, and that in all of the stumps I have seen, no muscle whatever covered the end of the bone, however much was left by the operator. Hence in these cases I left no muscle with the flap, which for the anterior was made from half the diameter of the thigh by cutting from without inward, making a semilunar flap of integument and fascia only, and the posterior by transfixion.

"These cases at the time of operation were very low with gangrene and pyæmia, yet three of them healed in less than three weeks with very little discharge, and a heavier covering than I had ever seen over

the end of the stump. The fourth one died of pyæmia in about two weeks, the stump being nearly healed."

Surgeon George J. Potts, 23d North Carolina Inf., prefers the circular operation: —

"I prefer the circular in all parts of the femur and humerus, the flap in the lower thirds of fore-arm and leg; and why? because when dividing the muscles in the thigh and arm the retractions are often so forcible that they assist the surgeon in forming a conical cavity for the covering of the stump. The grand aim in any operation is to save integument enough to cover the muscle, and muscle enough to cover the bone, and not to scrape off the periosteum. I think that there is less difficulty in seizing the arteries in the circular operation for the ligature, and that the surgeon is not so liable to ligate a nerve, or branches or twigs of nerves, as in the flap operation. I do not think that the oblique or straight division of the arteries, in either flap or circular, has anything whatever to do with the weight of testimony in favor of one or the other mode of operation." Surgeon Potts.

Assistant-Surgeon W. P. Moon prefers the oval of skin and circular of muscles: —

"In the majority of my amputations of arm, fore-arm, and leg, I adopted the oval of skin with circular of muscle from an impression that there was more muscular tissue to heal, and I thought I observed more resultant inflammation in the flap operation of my own and other cases. Assistant-Surgeon Moon.

"The only advantage in the 'oval' over the 'circular,' I conceive to be, that it is a handsome operation, and permits of more expedition. In opposition to this it requires more care and greater precision in making our initial incisions."

Surgeon R. J. Levis thus condemns in emphatic language the circular method: —

"Having had, during the war, under my observation probably a larger number of stumps of a defective character than any one else, I do most emphatically condemn the circular operation as being the method most frequently followed by stumps most tardy in healing, liable to leave an attenuated and tender cicatrix attached to the bone, and least suited to the adaptation of artificial limbs." Surgeon Levis.

Surgeon David P. Smith, United States Vols., makes the following observations in regard to the method of amputation of the leg: —

"Experience in many cases during this war has shown that the usual methods of amputating the leg in continuity are exceedingly faulty and often lead to deplorable results. The Surgeon D. P. Smith.

leg, being merely a means of progression, and its removal being more nearly compensated for than any other part of the body, will always be condemned to amputation more readily than any portion of the upper extremity. It behooves us therefore to employ the very best manual procedure possible.

"The mechanical difficulties to be avoided, are, —

"1. Protrusion of the spine of the tibia.

"2. Tender stump.

"3. Redundance of posterior flaps; in some instances forming a pendulous mass, and interfering greatly with adaptation of artificial limb.

"Protrusion of the spine of the tibia has occurred in every instance that came under the writer's notice during the war in which the posterior flap operation had been performed upon the field of battle. Transportation of the patient is sure to cause this. When we look at this form of operation and carefully observe all its defects, it seems amazing that it should ever have been practiced. The circular and the lateral flap methods are each of them superior to it in every respect.

"On account of the facility of execution, the complete freedom from all and any tension, the ready exit of pus, the freedom from pressure of all the important vessels and nerves, and the impossibility of any dragging of the flap against the spine of the tibia, the anterior flap method should, in the opinion of the writer, be preferred in all amputations of the leg in its continuity. It is best done in the following manner: —

"Standing on either side, transfix the limb one inch below the point at which you intend to saw the bones, passing the knife just behind the tibia and fibula, grazing both; then, keeping the flat of the blade closely applied to the bones, cut downwards for about five inches. Next, bringing the knife back to its first position, as when transfixing, cut downwards through the muscles of the calf, forming a flap of two inches in length. Now, carrying the disengaged knife over the front of the limb, connect the two lower extremities of the longitudinal transfixing cut by a curved incision, convexity downwards. Then dissect up the anterior flap from the bones and interosseal membrane, guarding against injury of anterior tibial artery by using the thumb-nail, or handle of the scalpel, to detach the muscle in its neighborhood. Use a small scalpel to cut around the bones and divide the periosteum, which do leisurely. Lastly, put on the retractor, and, as it is tightened, with your thumb-nails scrape upwards from the bones and all around the bones all the periosteum and muscular tissue, so that when the section is made, the same surfaces may be well covered with the one as well as with the other. Divide the bones on exactly the same level, remembering to saw off a very little from the upper and inner angle of the shin. It will now be seen that your anterior flap falls over the stump as naturally as the eyelid over the eye, and the pus finds as ready an exit as the tears.

"Acupressure needles can be used to control the hemorrhage in this amputation as well as in any other, but, inasmuch as they ought to be removed by some one entirely conversant with the subject at as early a period as possible, the carefully tied ligature, in battle-field surgery at least, is most applicable. Metallic sutures, and not plasters, should be used to close the wound.

"In some instances it may not be practicable to give the length herein recommended to the anterior flap. In such instances the posterior flaps can be made of greater length. The peculiar advantages of this form of operation are preserved if the anterior is two inches longer than the posterior flap.

"Many experiments upon the cadaver abroad before the commencement of the late struggle, showed that this was a most facile procedure, and experience in hospitals and on the field since then demonstrate its benefit to the patient."

It is the opinion of Assistant-Surgeon Leale that patients having amputation of leg suffer more than those who have had the thigh amputated. He says: —

"The patients as a rule with amputations through the tibia suffer more pain than those with amputated femurs, taking those at present in hospital as a guide."

DISTRIBUTION OF THE VARIOUS METHODS OF AMPUTATION IN THE DIFFERENT REGIONS OF THE THIGH AND LEG.

Method.	Upper third.		Middle third.		Lower third.	
	Thigh.	Leg.	Thigh.	Leg.	Thigh.	Leg.
Circular	10	38	22	27	20	50
Antero-posterior flaps	5	35	35	24	37	34
Posterior flaps	–	22	–	17	1	6
Anterior flaps	–	1	4	–	7	1
Lateral flaps	–	3	3	7	4	11
Rectangular flaps	–	–	2	–	3	–
Skin flaps and circular of muscles	–	4	–	–	2	4
Totals	15	103	66	75	74	106

We learn from this table that the circular operation was more frequently performed in the upper third of the thigh, in a given number of thigh amputations which recovered, than the flap. According to these statistics the former exceed the latter in the ratio of two to one. The number of cases is too few to establish the fact that the circular method gives a greater proportion of recoveries in this region, and we merely

Circular operation more frequent in upper third of thigh.

chronicle the record as an interesting, and perhaps important, conclusion presented by these statistics.

Flap operations most frequent in middle third.

In the middle of the thigh the proportion of circular to flap operations materially changes, and we find the latter predominating, and in the lower third this proportion is increased both by the increase of the flap operations and the diminution of the circular operations. This last result is quite unexpected, for the circular operation is generally regarded as especially adapted to the lower third of the thigh. We must either conclude that the circular operations more frequently proved fatal, or that this method was not so generally adopted at this point as the flap.

Methods of operation in the Confederate service.

The following table of thigh amputations performed by Southern surgeons during the war is of interest in this connection: —

AMPUTATIONS OF THE THIGH IN THE CONFEDERATE SERVICE (CHISHOLM).

Method.	Upper Third.		Middle Third.		Lower Third.		Total.
	Rec'd.	Died.	Rec'd.	Died.	Rec'd.	Died.	
Circular	21	18	40	28	54	48	209
Flap	10	5	18	19	40	16	108

The number of cases of amputation by the circular and flap operations in the upper third of the thigh which recovered, are in nearly the same proportion in this table as in the table already given. But we have also added the fatal cases, and in this collection the circular method gives a large excess of deaths. If this latter table correctly illustrates the comparative mortality after the two operations, the flap is far the most successful method of amputation in the upper third of the thigh. This excess of fatal cases of circular amputations we must consider as exceptional until further investigations prove it more definitely.

Circular method preferred in all parts of thigh.

It appears from this table that in the Confederate service the circular method was preferred to the flap method in all parts of the thigh. In Baer's consolidated tables,[1] we find 183 cases of thigh amputation recovered, of which 116 were the circular, and 67 the flap operation. These operations were distributed as follows: —

[1] Chisholm's *Military Surgery*, 3d ed. p. 395.

Method.	Upper Third.	Middle Third.	Lower Third.	Total.
Circular	22	40	54	116
Flap	9	18	40	67
Totals	31	58	94	183

The influence of the method of operation upon the mortality does not appear in our tables. From the consolidated table quoted from the statistics of the insurgent service, however, the following comparison may be instituted between 134 fatal cases, and the 183 recovered cases above tabulated: —

Method.	Upper Third.	Middle Third.	Lower Third.	Total.
Circular	18	28	48	94
Flap	5	19	16	40
Totals	23	47	64	134

These tables, properly reduced, give the following as the relative frequency of the two operations in the different parts of the thigh in the recovered and fatal cases, as reported by the Confederate surgeons: —

Method.	Recovered Cases.			Fatal Cases.		
	Upper Third.	Middle Third.	Lower Third.	Upper Third.	Middle Third.	Lower Third.
Circular	1 in 5.2	1 in 2.9	1 in 2.1	1 in 5.2	1 in 3.3	1 in 1.9
Flap	1 in 7.3	1 in 3.7	1 in 1.6	1 in 8	1 in 2.1	1 in 2.5

The almost exact correspondence of the proportion of circular and flap operations in the different regions of the thigh, both in the recovered and fatal cases, would seem to prove conclusively that the mere method of operating did not affect the mortality in the slightest degree.

Of the remaining amputations of the thigh, the anterior and lateral flaps seem to have been adopted in several cases in the middle and lower third. The rectangular flap of Teale was performed five times, twice in the middle third, and three times in the lower third. The operation by flaps of the skin and circular of

the muscles was performed but twice in the thigh, and on each occasion in the lower third.

Methods of operation in the leg.

Passing to the leg, we find the rival operations are the circular and antero-posterior flaps. The circular, in every region of the leg, however, presents the larger number of recovered cases. In the upper and middle third the difference in numbers between the two operations is not very marked; but in the lower third the preponderance of circular over the flap cases is very decided, and emphatically asserts the greater frequency of that operation.

We find here a large number of posterior flap amputations, limited principally to the upper and middle thirds of the leg. This operation is undoubtedly closely allied to the antero-posterior method in the leg, the anterior flap being short, and the posterior flap very long. The method by lateral flaps was performed in twenty cases, the largest number being in the lower third of the leg. In this operation we recognize the method by skin flaps and circular of the muscles, or an operation resembling it, owing to the nature of the tissues and part in which it was performed.

VII.

PERIOD OF AMPUTATION AFTER INJURY.

Period of operation after injury.

We have, in this collection, the period of operation fixed with great precision in 155 cases of thigh amputation, and in 276 cases of leg amputation, making a total of 431 cases of amputation in the lower extremity. We will first group them into primary and secondary operations according to the usual plan: —

Limb.	Primary.	Secondary.
Thigh	113	42
Leg	186	90
Totals	299	132

This table, in a striking manner, confirms the now well-established fact that primary amputations in military surgery are far the most successful. In a given number of recovered cases, taken indiscriminately, we find the primary amputations exceed the secondary more than two to one. That this statement may be accepted

as a general truth is proved by the following statistics, which are gathered from various sources, and represent only recovered cases:

	Thigh.		Leg.	
	Primary.	Secondary.	Primary.	Secondary.
Above collection	113	42	186	90
Sherman's campaign (Andrews) . .	53	26	60	7
Confederate army	224	56	96	18
British army (in Crimea)	53	6	61	4
Hospitals on Bosphorus	36	6	30	4
	479	136	433	123

Primary amputations 77.8 per cent. of recovered cases of thigh.
Primary amputations 77.8 per cent. of recovered cases of leg.

This table furnishes not only the strongest possible evidence of the success of primary amputations over secondary, but we find in it also a singular coincidence between the results of the primary and secondary amputations in the thigh and leg. It is found on reducing this large collection of cases that there is precisely the same percentage of primary amputations in both the thigh and leg, and that the percentage is more than three fourths of the recovered cases.

But while the success of primary over secondary amputations has been definitely determined, and the principle that the former should always be preferred to the latter has been incorporated as a maxim into military surgery, there has been a growing disposition manifested to study more thoroughly the influence of periods upon the results of amputation, and by a wise discrimination establish new and more practical subdivisions than those hitherto known as primary and secondary. It has long been apparent to careful observers that, after the receipt of a severe gunshot injury of an extremity, the patient passes through several well marked stages or periods, in which his general condition and the wound undergo very material changes. At first he suffers from the shock or *ebranlement;* this is followed by reaction; then succeeds the preliminary stages of inflammation; and finally the inflammatory stage with suppuration supervenes, and the progressive changes through which wounds pass to recovery. The first period can last but a few hours; the second may extend to twenty-four or forty-eight hours; the third may continue several days before the fourth is established; and the fourth may continue

Importance of a new division of the periods of amputation.

an indefinite period. Competent observers describe still another stage, namely, that which intervenes between the receipt of the injury and the commencement of the shock.

Various divisions of periods of amputation.

Writers on military surgery have variously divided these periods, but in general they have added only one subdivision, and that has been intermediate between the primary and secondary periods. Boucher, followed by Alcock, made the following distinctions, namely, the *primary*, the *intermediate*, and the *secondary*. H. Larrey distinguished three periods, as follows: the *immediate* or *primitive*, the *consecutive*, and the *ulterior*. Legouest made three divisions, namely, the *immediate*, the *mediate*, and the *ulterior*. J. Roux gave the following titles to his subdivisions, namely, the *immediate* or *primitive*, the *mediate* or *secondary*, and the *ulterior* or *consecutive*. In these new divisions the period which intervenes between the commencement of the inflammation and the commencement of suppuration was regarded as intermediary, consecutive, or mediate. These distinctions have for the most part been made by French writers. Legouest thus defines the meaning and application of the terms which he employed, namely, *immediate*, *mediate*, and *ulterior*: an amputation is immediate when it is practiced before the development of inflammatory phenomena; it is *mediate* when made during the inflammatory period; and it is *ulterior* when practiced at the time that the lesion becomes local, and may be regarded as a chronic affection. It will be perceived that Legouest overlooks altogether the period of shock, and the same is true of the other authors quoted.

Professor Hamilton, of New York, has made a new classification of the periods of amputation, in which he divides the primary period of Boucher, and the immediate period of Legouest, into the *immediate* and *primary*. He remarks of this division:[1] "These periods are divided somewhat arbitrarily into immediate, primary, intermediate, and secondary, which arbitrary divisions have relation to certain supposed physical conditions of the patient during these periods. It is assumed that the conditions correspond, therefore, to certain divisions of time with some degree of accuracy. It being assumed that in a certain proportion of cases within the first six hours the patient is in a condition of shock, this is called the 'immediate' period. It being assumed that after the lapse of six hours, and before forty-eight, reaction ensues, but not inflammation, this is called the 'primary' period,

Hamilton's division of periods.

[1] *Med. Record*, September 15, 1866.

or period of reaction. It having been observed that after the lapse of forty-eight hours, and before the interposition of suppuration, which is usually completed by the seventh day, there is inflammatory action or a congestion of the limb, this is called the period of inflammation or of congestion, or the 'intermediate' period, as being intermediate between the primary and secondary. And it being assumed that suppuration takes place, or is pretty well developed, by the seventh day, the period extending from this time on is called the 'secondary' period. This latter period is indefinite as to its extent, and is also called the period of suppuration."

In these several classifications of the periods into which we may divide the stages of progress of gunshot wounds of the extremities, no notice is taken of that still earlier period which intervenes between the receipt of the injury and the shock, to which we have already referred. Those writers who recognize this period regard the shock as delayed, giving, thereby, a period more important, with reference to the operation, than any which follow. Paré alluded to this period, though perhaps without recognizing the absence of shock, and urged that amputation should be made while the wounded were in sight of the battle-field. Wiseman refers to it in this emphatic language: "If you decide to operate, do so at once, while the soldier is in heat and in mettle." Larrey recognized it, and declares that amputation should be performed at once. Hutchinson,[1] a distinguished British naval surgeon, proves by a large experience that there was a distinct interval between the injury and the occurrence of shock. His observations were made on shipboard, where he had an opportunity to see the patient from the moment of injury. Quarrier,[2] also a naval surgeon, speaking of a naval action in which he was engaged, says: — Period before shock.

"All our amputations were performed immediately, without waiting for reaction; and it may be necessary to observe, that though many of the men were carried down with their limbs torn from them, others with the most severe lacerations and fractures, ... yet in no instance could we perceive the dreadful perturbation and constitutional shock so frequently described by authors on gunshot wounds, until some time after the injury was received."

He adds: —

"I have every reason to conceive, that amputation having so promptly followed the wound, was the only effectual means of saving many from its baneful influence."

1 *Practical Observations in Surgery.* 2 *Med. Chir. Transact.* vol. viii.

Surgeon Lidell, an accurate observer, and in charge of a large military hospital during the late war, believes that the shock is generally delayed, giving a period favorable for the operation.

Surgeon C. J. Walton, 21st Kentucky Vols., says: —

"In some cases there is a period of time sufficiently long between the reception of the injury and the 'shock.' Beyond all doubt this is the most favorable time for an operation. The patient then only receives one 'shock,' and the recovery is rapid, and almost invariably successful."

Surgeon D. F. Leavitt, 3d Massachusetts Cav., writes: —

"Shock after severe injuries has not been frequent under my observation. Two cases only among many hundred severe injuries have suffered in a marked degree from shock — one a compound comminuted fracture of head of tibia by large grape-shot; the other, compound comminuted fracture of femur at trochanter by small grape-shot. Both died without hemorrhage. No operation was performed."

Finally, we have the evidence of McLeod, not only as to the existence of this stage, but as to its importance with reference to the operation. He says:[1] —

"I know of several well authenticated cases which occurred during the siege, in which the perfect absence of all constitutional prostration after an accident so severe as the carrying off of a limb, and the non-appearance of such shock for some considerable time after, went to prove the same position."

In view of such testimony it seems important to recognize a fifth period, which becomes truly that of *the immediate* amputation, namely, the period which intervenes between the receipt of the injury and the shock. This period would not ordinarily extend beyond an hour.

A fifth period recognized.

It may be stated here that these divisions of time cannot be fixed in any given case. They depend upon physical conditions that change with individuals and with surrounding circumstances. Inflammation may occur within twelve hours of the injury, or by treatment it may be delayed three or four or more days. The periods that have been fixed, and the terms that have been employed to designate changes, are arbitrary, and are to be taken in the most general and liberal sense. In the redivision of these periods terms ought to be adopted that clearly define the meaning of those who use them in every individual case. The old terms primary and secondary, though

Periods should designate the condition of the patient.

[1] *Notes on the Surgery of Crimean War.*

applied to two very well understood divisions of time which embraced certain conditions of the local injury, were rarely so employed as to convey a definite meaning. The science of our day demands more positiveness in the nomenclature of diseases.

It would be far better, therefore, in making a new classification of periods, to select terms which explain the existing condition of the patient or wound, and which are not arbitrary. We propose for the purposes of discussion in this paper to so divide the periods as to include all hitherto described, and under such titles as more nearly explain the condition of the patient or part. We name five periods, as follows: *before shock* (one hour or less); *during shock* (one to six hours); *during reaction* (sixth to forty-eighth hour); *primary inflammation* (forty-eighth hour to seventh day); *secondary inflammation* (after seventh day). The first two periods relate to the condition of the patient, and the last two to the condition of the wound.

New names of periods.

Much difference of opinion exists among writers as to the propriety of amputations in these different periods. This question can be correctly settled only on the basis of the comparative mortality in each. The preceding collection of cases furnishes us the materials for forming correct conclusions upon this much debated subject. We are able to fix the time of operation in each case with so much exactness that we are enabled to determine the proportion of recoveries, in the different periods, to the total recoveries, and thus determine the most favorable period for the operation. We will first present an analysis according to the divisions of Hamilton.

Propriety of amputations in each period.

NUMBER OF CASES IN FOUR HUNDRED AND THIRTY-ONE RECOVERED AMPUTATIONS IN THE IMMEDIATE, PRIMARY, INTERMEDIATE, AND SECONDARY PERIODS, AND THE PER CENT. IN EACH PERIOD OF TOTAL AMPUTATIONS IN THE THIGH AND LEG.

	Immediate.	Primary.	Intermediate.	Secondary.
Thigh,	52, or 33.5 per ct.	49, or 31.6 per ct.	18, or 11.6 per ct.	36, or 23.2 per ct.
Leg,	104, or 37.6 per ct.	82, or 29.7 per ct.	35, or 12.6 per ct.	55, or 19.9 per ct.
	156	131	53	91

SUMMARY.

Immediate,	156, or 36.2 per ct. of total.	Intermediate,	53, or 12.3 per ct. of total.
Primary,	131, or 30.4 per ct. of total.	Secondary,	91, or 21.1 per ct. of total.

If we divide the cases included in the *immediate* period into those occurring within one hour, and those occurring between the

first and the sixth hour, we should separate those operated upon before, from those operated upon during the shock, or nearly so, as follows: —

	Before shock.	During shock.
Thigh	18, or 11.6 per cent.	34, or 21.6 per cent.
Leg	24, or 8.6 per cent.	80, or 28.7 per cent.
	42, or 9.7 per cent. of total.	114, or 26.5 per cent. of total.

Propriety of immediate amputation.

In regard to the propriety of amputation immediately after the occurrence of the injury, or before the shock is of any considerable intensity, as within one hour from the gunshot, various opinions are held. Paré and Wiseman evidently approved of immediate amputation in the sense in which we speak of it, namely, *before the shock*. Larrey advocated with great earnestness immediate amputation, and affirms that he lost a great number of patients by delay. He speaks of being most successful in cases where the operation was *peu d'instans apres le coup*. McLeod, speaking of the period which intervenes between the wound and the shock, says: "If this precious moment could be seized at all times, and that operation performed under chloroform, which assists so much in warding off the *ebranlement* we fear, how much more successful would our results prove than under any other circumstances they ever can be!" Hutchinson says: "The operation *ought not to be deferred* ONE MOMENT!"

Guthrie says: "There can be no doubt that if the knife of the surgeon could in all cases follow the ball of the enemy, or the wheel of a railway carriage, and make a clean, good stump, instead of leaving a contused and ragged wound, it would be greatly to the advantage of the sufferer." He approves, in general, of immediate amputation in the arm or below the knee, remarking: "These operations may be done at any time from the moment of infliction until after the expiration of twelve or twenty-four hours, without any detriment being sustained by the sufferer with regard to his recovery." In those cases where the injury renders amputation in the upper third of the thigh or at the hip joint necessary, he is in doubt as to the propriety of immediate amputation, and thinks the subject demands further investigation.

Hamilton[1] believes that the occurrence of delayed shock is rare, and would approve of immediate amputation only in extreme cases, "as, for example, when a limb is nearly torn off, and a dangerous hemorrhage, which cannot be arrested, is occurring; or when spicula of bone, such as neither the forceps nor fingers can

[1] *Med. Record*, September 15, 1866.

extricate, are causing intense suffering." He would also favor immediate amputation "in a considerable number of cases of injuries to larger limbs, when it is clearly seen that the patient is not faint, or depressed, or suffering under great nervous agitation."

Results of immediate amputation

The above table shows that amputation was successfully performed during the late war within a period after the injury which implies either that shock had not supervened, or that it was as yet but slight. In many cases the operation is reported to have been performed immediately, and some of these we know were immediately, in the true sense of the word, but a few minutes having elapsed between the receipt of the injury and the operation. It may be stated in regard to the comparatively few cases reported, that they prove that a large mortality must have occurred, or that but few operations were performed. We incline to believe the latter is the true explanation. The opportunity to perform an amputation within an hour after the injury, occurs but infrequently compared with the cases which offer for amputation at subsequent periods.

Amputation during shock.

Various opinions are advanced by military authorities in regard to amputation during the existence of shock. Larrey went so far as to contend that the nervous "commotion" was rather an indication of the propriety of the operation, because its effects "far from being aggravated, diminish and disappear insensibly after the operation." McLeod, quoting this statement of Larrey, says: "But even although that constitutional disturbance which is the result of injury is present, is it always necessary to wait its subsidence before operating? If it be very decidedly marked, and the patient thus much prostrated, such delay may certainly be called for; but it is an opinion often stated by those who must be well informed on the subject, that such delay is not always advantageous, but manifestly the reverse."

Hamilton decidedly condemns amputations during the stage of shock. He remarks that his experience has been, "after at least twenty years of observation in hospital practice, and after a pretty large experience upon the field, that amputations of large limbs, made after severe injuries and before reaction has fairly been established, have in most cases resulted speedily in the death of the patients." The cases to which Larrey refers, in which the nervous commotion is diminished by an operation, he explains to be those in which the broken bones, fragments of shell, splinters, clothing, or some other foreign substance lying in the track of the wound, are causing pain, and perpetuating the irritation.

Success of amputation within six hours of injury.

The preceding table would seem to definitely settle the question of the advantages of amputation within six hours of the injury. And this period includes the limits set by Hamilton to the stage of shock. Thirty-six per cent. in a total of four hundred and thirty recovered amputations, embracing all periods after the injury, were performed within six hours of the receipt of the wound. These statistics prove that immediate (Hamilton) amputations of the thigh and leg, that is, those performed before and during shock, are six per cent. more successful than those performed after reaction comes on and before inflammatory symptoms appear; three times as successful as those performed in the intermediate period, or in the stage of primary inflammation; and, finally, nearly twice as successful as the secondary operations.

Comparing the thigh and leg amputations, it will be seen that the largest percentage of recovered cases in the immediate period occur in the leg.

If we analyze the immediate amputations by dividing this period into two, the first of one hour, and the second from one to six hours, or into the amputations before the shock, and during the shock, we find that 9.7 per cent. were performed in the first period, and 26.5 per cent. in the second period. It is to be noted also that amputations before the shock were three per cent. more favorable in the thigh than in the leg.

Period of reaction.

The period of reaction extends from the sixth to the forty-eighth hour. During this time the wound remains in a comparatively quiescent state. The patient rallies and recovers his normal general condition, and seems to be in a proper state for an operation. But these tables prove that the success of amputations in this period is not as great as before, or during the shock, or rather that in a given number of recovered cases the largest percentage occurs in the earlier periods. From this fact we learn that primary amputations are successful in proportion to the number that are performed before the stage of reaction commences. Heretofore the period of primary amputations has included the three periods above designated, namely, that before, and during the shock, and the stage of reaction; and the general opinion of surgeons was that the successful amputations mostly fell in the third period, or were performed in the stage of reaction. By this discrimination of time, and the more careful designation of the periods within which operations were performed, we learn that the real value of primary amputations depends upon whether they were performed before the stage of reaction.

The great fatality of amputations performed in the "intermediary" period, or during the excitement which precedes suppuration, is strikingly illustrated in these tables. By far the smallest percentage of recoveries are reported for this period. This unfavorable result is not so much due to the condition of the wounded parts, as to the general condition of the patient. The system is now suffering from the first onset of inflammatory fever, and there is necessarily a high degree of vascular and nervous excitement. The temperature of all the tissues of the body is raised by the blood surcharged with heat from the inflamed parts, and there is consequently an exalted tissue sensibility. The shock which follows an operation under these circumstances is always most profound, and reaction correspondingly difficult and uncertain. The inflammation which supervenes is also more destructive of tissue, and exhaustive of the patient. These circumstances combine to render the intermediary period more dangerous than any preceding.

Intermediary period.

The secondary period, which includes all operations performed after the seventh day, is seen to give a larger percentage of recoveries than the intermediary period, but the results are not as favorable as in either of the two earliest periods, namely, before, and during the shock. We have in this result only the general conclusions of military surgeons, long since established, that the secondary amputations are more fatal than the primary; but we had not before so discriminated the divisions of the stages through which the patient passes, included in the primary period, as to determine at what precise time the least and greatest mortality occurred. We now discover that secondary amputations are not as successful as primary amputations at any period within the first forty-eight hours.

Secondary amputations.

We may conclude in regard to the success of amputations at the different periods as follows: —

General conclusions in regard to success of amputation at different periods.

1. Immediate amputations, or those performed *before the shock*, give good results in military surgery.

2. Amputations performed between the first and sixth hour after the injury, or *during the shock*, are more successful than when performed at a later period, but are not probably more successful than when performed immediately.

3. Amputations performed between the sixth and forty-eighth hour, or in the period of reaction, are more successful than at any subsequent period, but are not nearly as successful as amputations performed previously to the sixth hour.

4. Amputations performed between the forty-eighth hour and seventh day, or in the intermediary period, are more fatal than at any time prior or subsequent to that period.

5. Amputations performed after the seventh day, or in the secondary period, are more fatal than amputations performed at any time prior to the forty-eighth hour after the receipt of the injury.

TESTIMONY OF SURGEONS AS TO THE PERIOD AT WHICH AMPUTATIONS SHOULD BE PERFORMED.

Surgeon D. F. Leavitt, 3d Massachusetts Cav., says: —

"Amputation immediately after injury I think affords the best chance of recovery. If the patient is suffering from shock, I think sulphuric ether should be administered whether operation is required or not, it being, so far as I have observed, the best treatment for that condition. If time for primary operation has passed, and there are no urgent reasons for early secondary operation, such operation need not be performed until sufficient reasons aside from the ultimate usefulness of the limb exist. In capital operations such a course affords most chances of recovery. Other things being equal, a late secondary operation furnishes better chances of recovery than an early one performed while inflammation is acute, and the system has not had time to adapt itself to the burden it already has to bear."

Surgeon C. J. Walton, 21st Kentucky Vols., says: —

"The earlier an amputation is performed after the injury is received, the more successful will it be, unless the 'shock' is too great to justify operating immediately; then, of course, we should wait for reaction."

Surgeon P. H. Bailhache, 14th Illinois Cav., says: —

"Primary amputations are almost always successful, while intermediary and secondary are generally fatal, particularly in general hospital practice. Of some thirty-five primary operations only two deaths occurred, one of these from malarial poison; while of ten cases of secondary amputation eight died."

Surgeon B. W. Avent writes: —

"I have for many years advocated the immediate procedure in uncomplicated shock. The experience afforded during the last few years has greatly strengthened my former convictions. The principle which controls me in this selection is not alluded to by yourself or those to whom you refer; nor have I been able to find it elsewhere. Larrey

may mean something of the kind, when he speaks of loss of patients, because his operations were, in some instances, too long deferred; but his language is not explicit. In the limits of a letter I can merely mention the grounds upon which I act. The premises may be untrue, but the results have been more satisfactory, as a general rule, than in either the primary or secondary selection. I give it as follows: —

"1. Shock, following gunshot wounds, or other injuries of a kindred character, is purely nervous. 2. The impression is both local and constitutional. 3. Susceptibility to further impression is suspended proportionally to the recognized manifestation upon the subject. 4. Loss of blood is not essential to the production of nervous shock, but to a limited extent may be regarded as remedial in its effects. 5. Anæsthesia may be employed with entire safety during any period of shock, though in many instances where the operation is near the wound, owing to the absence of sensation, this agent might be dispensed with.

"I never adopt the immediate procedure when there has been serious loss of blood. Many of the failures incident to it, in my judgment, are referable to a want of discrimination at this point. The respective conditions from shock and loss of blood are so entirely dissimilar that but little experience is required to detect them. They are, however, often overlooked.

"I remarked just now that loss of blood when limited is remedial in shock. I think there is no principle in surgery more conclusive."

VIII.

INFLUENCE OF THE PLACE OF AMPUTATION UPON THE AMOUNT OF ATROPHY OF THE STUMP.

Among the final results of amputations, atrophy of the stump must be regarded as of the first consideration. Next in value to a firm and durable covering to the stump is a well nourished extremity. If the stump undergo progressive atrophy, the artificial limb requires much more care to maintain its adaptation. The constant shrinkage of the extremity renders the appliance loose, and hence it requires readjustment by continuous padding of the socket. This padding of the socket is not required when the limb maintains its full dimensions. Atrophy of stump.

The accompanying tables enable us to determine how far the method of operating, and the point of the limb at which the amputation is performed, influence the subsequent nourishment of the stump. The measurements were made when the stump was healed, and prepared for the final adjustment of the artificial limb. The first or proximal measurement was made, in the thigh, at the high-

est point where the circumference could be taken, and in the leg, immediately below the knee. The second, or distal measurement, was made directly around the extremity of the stump, at a point where the margins of the flap begin to incline towards the cicatrix. The figures entered in the tables under the head "atrophy," express the difference in inches and fractions of an inch between the measurement at the points above indicated of the mutilated and uninjured limb.

COMPARATIVE AMOUNT OF ATROPHY OF STUMPS IN THE UPPER, MIDDLE, AND LOWER THIRDS OF THE THIGH AND LEG, IN AN AGGREGATE OF 430 CASES.

(*In inches and fractions of inches.*)

Limb.	Upper Third.		Middle Third.		Lower Third.	
	Proximal.	Distal.	Proximal.	Distal.	Proximal.	Distal.
Thigh	0.45	1.05	1.56	1.70	1.34	2.08
Leg	0.97	1.70	0.71	1.42	0.57	2.26

It must be borne in mind that the proximal measurements in the thigh are all made at the same point; and the same is true of the leg. It would appear from this table that the point of amputation exercises a very marked influence upon the degree of atrophy of the stump, both in the thigh and leg. In general, the amount of atrophy progressively increases as we recede from the trunk, an exception, however, being noticed in the middle third of both the leg and thigh, which we shall presently notice. In the thigh the proximal atrophy is least in amputation in the upper third, and greatest in amputations in the middle third. In amputations in the lower third of the thigh, the proximal atrophy is slightly less than in those performed in the middle third, but still it is three times as great as after those in the upper third. This fact proves a progressive proximal atrophy as the point of amputations in the thigh recedes from the trunk. In the leg this rule is reversed, and the proximal atrophy diminishes as the point of amputation recedes. And this atrophy diminishes in regular order, being least in amputations in the lower third of the leg.

Proximal atrophy not increased by inflammation.

It must not be supposed that the proximal atrophy is influenced by the amount of inflammatory thickening subsequent to the operation, for in that case the degree of atrophy would in general depend upon the proximity of the amputation to the point of measurement. But this is by no means the case.

Amputations in the middle third of the thigh, near the point of measurement, are followed by a greater amount of atrophy than those in the lower third, remote from that point; while in the leg the largest amount of atrophy is in amputations near, and the least in amputations remote from the point of measurement.

The distal atrophy, or that which occurs at the extremity of the stump, has in the thigh a progressive increase as we proceed from the trunk, being about twice as great in the lower as in upper third. In the leg, on the contrary, the least distal atrophy occurs in the middle third, while that of the lower extremity is not so great compared with that of the upper extremity, as was found existing between the upper and lower thirds of the thigh.

Distal atrophy in thigh and leg.

Comparing the atrophy of the stumps in thigh and leg amputations, we notice that the proximal atrophy is greater in amputations in the upper third of the leg than in the same region of the thigh, while in the middle third it is more than twice as great in the thigh as in the leg, and in the lower third the excess of atrophy is greater in the thigh in proportion than in the leg. The distal atrophy varies very markedly as follows, namely: in the upper third it is greater in the leg; in the middle third it is greater in the thigh; and in the lower third it is greater again in the leg.

These facts may be stated in general terms as follows: —

1. In the thigh, the farther amputation is performed from the trunk the greater will be the atrophy of the entire stump.

Conclusions in regard to atrophy.

2. In the leg, the farther amputation is performed from the trunk the greater will be the atrophy of the extremity of the stump, and the less the atrophy of the body of the stump.

IX.

INFLUENCE OF THE METHOD OF AMPUTATION UPON THE ATROPHY OF THE STUMP.

We next proceed to inquire as to the influence of different methods of amputation upon the nourishment of the stump. The following table contains a distribution of the several methods of amputation in the thigh and leg, with a computation of the average amount of atrophy following each: —

Influence of method of amputation upon atrophy.

COMPARATIVE AMOUNT OF ATROPHY OF STUMPS AFTER AMPUTATION BY VARIOUS METHODS IN THE UPPER, MIDDLE, AND LOWER THIRDS OF THE THIGH AND LEG.

(*In inches and fractions of an inch.*)

THIGH. (*Total number of stumps*, 157.)

Method.	Upper Third.		Middle Third.		Lower Third.	
	Proximal.	Distal.	Proximal.	Distal.	Proximal.	Distal.
Circular	0.7	0.7	1.4	1.9	1.6	2.5
Antero-posterior flaps .	0.2	1.4	1.1	1.6	1.6	2.4
Lateral flaps	–	–	1.8	1.8	1.6	2.3
Anterior flap	–	–	2.5	2.2	1.3	2.4
Rectangular flap . . .	–	–	1.0	0.0	2.0	2.8
Skin flaps and cir. muscles	–	–	–	–	0.6	1.5
Posterior flap	–	–	–	–	0.7	0.7

LEG. (*Total number of stumps*, 287.)

Circular	1.1	1.5	1.0	2.3	0.5	2.3
Antero-posterior flaps . . .	1.1	1.3	0.4	1.1	0.1	2.7
Posterior flap	1.3	1.1	0.5	2.2	1.	2.6
Lateral flaps	0.4	2.9	1.0	1.0	0.7	2.6
Skin flaps and circular . . .	–	–	–	–	0.5	1.1

Influence of various methods of amputation upon nourishment of the stump.

This table illustrates in a very striking manner the influence of the various methods of forming the covering of the stump upon the nourishment of its cicatricial tissue. The difference in the amount of atrophy of the distal extremity evidently depends upon the extent to which the arterial supply has been sacrificed. In the thigh the arteries which are distributed to the muscles are principally in the upper third, from the femoral branches immediately below Poupart's ligament, and in the middle and lower third from the profunda.

Effects of circular and flap.

In the upper third of the thigh, therefore, a circular amputation would divide the branches of the femoral at a higher point than an antero-posterior flap, — in which the posterior flap is usually longer than the anterior, — and hence the atrophy would be greater in a stump formed by a circular than in one formed by an antero-posterior flap. The same rule would apply to these operations in other parts of the thigh, though perhaps not so markedly.

The method of operation by lateral flaps does not differ materially, in respect to the degree of atrophy, from the circular, and the results of the two are seen to be very similar.

The method of operation by making an anterior and a rectangular flap, differs in this important respect from the preceding methods, namely, that the flap is made wholly from the anterior part of the limb, while the tissues are completely divided to the bone in a perpendicular direction on the posterior aspect of the limb. By these methods the principal covering of the stump is poorly supplied with nourishment, and hence atrophy would be more likely to occur. This is seen to be the case especially in the anterior flap method in the middle third, and the rectangular flap in the lower third.

Rectangular flap.

The methods which give the least atrophy of the stump, both in its proximal and distal portions, are the skin flaps and circular of the muscles, and the posterior flap. It is not difficult to understand why the posterior flap method gives results so favorable; it leaves quite intact the full vascular supply to the entire covering of the stump. In this respect it might well be regarded as the best method of operation in the thigh, but these advantages are so counterbalanced by the tendency of the flap to retain pus, its heavy and unsuitable position for transportation, etc., that it has but few advocates. The method by skin flaps and circular of the muscles gives results nearly as favorable as the posterior flap, and much more favorable than any other of the preceding methods. It is greatly preferable to the posterior flap method, both on account of the facility of drainage, and the neat apposition and lightness of the flaps, thus adapting it to transportation.

Skin flap and circular of muscle.

The influence of the various methods of operation upon the nourishment of the stump is not so well marked in the leg as in the thigh. This is unquestionably due to the peculiarity of the arterial distribution. The larger trunks are numerous, and are deeply situated in immediate relations with the bones. They are not, therefore, liable to division until the operation is about to be completed. There would therefore be but little difference among these operations as regards the vascular supply of the flaps, except so far as the extent of the flap should modify the ultimate distribution of arteries. A long flap would necessarily have less supply than a short flap, and would be more liable to immediate death and future atrophy. Of the different methods it will be noticed that the skin flaps and circular of the muscles gives the least atrophy in the leg as well as in the thigh.

Effect of various methods in the leg.

Many of the disastrous results of amputation in the lower extremities have been attributed to immediate transportation. To this cause have been referred sloughing of flaps, gaping

Effect of transportation.

of wounds, protrusion of bone, etc. There is, undoubtedly, some truth in this very prevalent opinion, and yet the statement must undergo certain modifications. There were innumerable instances in which men suffering from recent amputations of the lower extremity, had their wounds so imperfectly dressed and supported, were so crowded and confined, and were so rudely transported, that the most unfortunate consequences ensued. But unfavorable results under such circumstances are not justly due to simple transportation, but rather to that want of care in the preparation of the patient, and the conditions surrounding him, which military exigencies necessitate or which are the result of negligence.

There are abundant facts to prove that the transportation of recent amputations, when judiciously managed, is attended with the most happy results. During the long marches of Sherman's army from Atlanta to Savannah, and from the latter place northward, an opportunity was offered of determining the effects of transportation upon recent amputations. As soon as the amputation was performed, and the wound properly dressed, the patient was placed in the ambulance or army wagon, and there remained until the army reached its destination. It is the testimony of surgeons who had the care of these men, that their wounds healed with but little suppuration, sloughing did not occur, and scarcely a case proved fatal. Most of the amputations, made on the first, second, or third day's march, were entirely healed when the army reached Savannah. It should be stated that the army marched through a pleasant country, and with good roads; the men were in good physical and mental condition, and the supply of fresh food of every description was abundant.

The following testimony of surgeons upon the question of the dangers of transportation to the recently amputated is important: —

Surgeon J. C. Walton, 21st Kentucky Vols., says: —

Surgeon Walton.

"My observation proves that soldiers laboring under wounds not *involving fracture* of the long bones, or who have undergone *amputation*, bear transportation remarkably well, and often express themselves as feeling improved, after being moved several miles over rough roads."

Surgeon P. H. Bailhache, 14th Illinois Cav., writes: —

Surgeon Bailhache.

"It is surprising with what ease recent cases of amputation bear transportation. I have witnessed little or no bad effects therefrom in some twenty-five or thirty cases."

Surgeon Charles E. Deming, 28th Ohio Vols., says: —

"In nothing have I been more astonished than the very inconsiderable injurious effects of transportation upon recent amputations of the inferior extremities. I have seen men with amputated thighs, legs, and arms, transported sixty or seventy miles over the roughest of roads, in wagons, without producing any very serious consequences. Care should be taken to keep the stump constantly wet with cold water by an attendant, whose duty it should be to steady the limb when passing over very uneven places. Surgeon Deming.

"Wagons filled with hay afford the best means of transportation over roads; ambulances jolt and rock too much."

Surgeon E. Batwell, 14th Michigan Vols., says: —

"No point of practice was so difficult to decide as the treatment of gunshot fractures. On one side we had what seemed to be a simple compound fracture, with no great apparent comminution or laceration of the soft tissues, whilst on the other, we had statistical evidence of the fatality arising from endeavoring to save the limb. Out of six cases of compound fracture arising from gunshot wounds, after the battle of Jonesboro', but *one* recovered, and that too under the most favorable circumstances. The transportation to Atlanta was over a level sand road, and the dressing of the wounds was performed by skillful and efficient surgeons, *regularly every day*. Every requisite was furnished to mitigate suffering or to afford comfort, by the Sanitary Commission; but the result proved that if the limbs had been removed, a very different state of things would have followed; for out of thirty-five cases of amputation but *four* proved fatal, and two of these were secondary operations. Such success in operation we consider unprecedented, and we feel some just pride at the results gained. Surgeon Batwell.

"I look on immediate transportation as not productive of half the danger to a patient as if necessity required us to remove them at a later period. The request I would myself make, if I had received a compound fracture from a gunshot wound, would be to have immediate amputation performed.

"When Sherman swung his army to the south of Atlanta, a man was brought to hospital, and his left leg taken off at the upper third of the thigh, and before he was well out from the influence of chloroform, he was put into an ambulance, and continued to move with the army daily for seven days. He improved rapidly, and his wound was almost united on arriving at Atlanta, and in sixteen days he was sitting up, and in twenty was on crutches.

"When obliged to move cases of amputation of the lower extremities, I placed the stumps in slings suspended from the top of the ambulance; by this all jolting was lessened, and the patients could save themselves much agony by holding and raising themselves; besides, they

could move and change position with far greater facility, and turn on their side without hurting or knocking the stump. I found that in our stationary hospitals this same plan, carried out by a simple frame across the cot, afforded the very greatest ease to our patients, both as regards facility of movement and dressing; besides, the wounds were very easily protected from flies, and the subsequent effects of maggots were thus obviated. You also had a better chance of applying cold water without drenching the bed, or any other application deemed necessary."

Surgeon B. T. Kneeland, —— New York Cav., says: —

Surgeon Kneeland.

"My experience in transportation of those who have suffered amputations is limited to army wagons, and I was frequently surprised to witness the improvement of patients when thus removed, often exceeding that of patients confined to hospitals."

X.

THE INFLUENCE OF DIFFERENT METHODS OF AMPUTATION IN THE SEVERAL REGIONS OF THE THIGH AND LEG, ON THE RAPIDITY OF THE HEALING PROCESS.

Influence of different methods of amputation on healing.

There is an opinion very prevalent among surgeons, both in civil and military practice, that there is a marked difference in the rapidity with which amputation-wounds heal, depending upon, 1st, the region in which the operation is performed; and, 2d, the method employed. It is necessary, of course, in estimating this difference, to discriminate carefully the cases selected, and place them upon precisely the same basis as regards their condition. If two operations are compared in this particular, the patients must be equal quantities in every respect, otherwise our conclusion will be vitiated by a preponderance of favorable or unfavorable conditions. Nothing would be more difficult than to select two patients thus equally balanced.

Sources of error.

It is quite impossible to determine whether any, and what, differences exist in the healing of these wounds, except as we take the averages of large numbers situated under nearly the same circumstances; and even then our deductions can only approximate the truth. In this collection we are able to group together a large experience in amputations of the lower extremity, and determine in a somewhat definite manner the period of healing of the amputation-wounds. It is true that there are many circumstances incident to the healing of wounds in military surgery, which tend to vitiate our conclusions, such as injurious transportation, insufficient food, sloughing of flaps from gangrene, necrosis, etc., etc. But in grouping together a large number of cases, all

having been subjected to the same untoward influences in a greater or less degree, the average results are rendered in a certain degree truthful.

Amputations are frequently pronounced cured when the wound is not completely closed, the surgeon having reference rather to the safety of the patient and his ability to leave his bed than to the actual condition of the stump. But in the sense in which we are to regard the patient as cured, the condition of the stump alone is to be considered. No stump can, in this connection, be pronounced cured when the wound is not healed, and the cicatrix is not so far perfected as to admit the adaptation of an artificial limb. When a patient is cured.

In the preceding tables a note is made of two examinations of the stump, the first, when the patient first came under observation, and the second, when the stump was ready for the adjustment of the artificial leg. In regard to the first examination, it should be stated that in general it was made when the surgeon discharged the case as cured, and when the stump was thought to be sufficiently healed for the proper measurements for the artificial limb. In many instances the wound was already completely cicatrized when the patient first presented himself for examination. In such cases the date of the completion of the cure is not stated. This column gives, therefore, merely approximate results. We can learn from it only that within given periods a certain number of stumps were completely cicatrized, and that a certain other number were not healed. The condition of the stump is generally noted, and the causes which led to its non-cicatrization are briefly specified.

In the second column the date of the application of the artificial limb is given. At this period the stump was healed and in a condition suitable for use. This period did not always mark the exact date of the perfection of the cure, as in some instances the stump had been healed for a considerable time. But in general it may be assumed that the date of the adjustment of the artificial limb marks the period of the completion of the cure, and the final discharge of the patient.

The following table contains the results of a computation of the average periods of the healing and non-healing of stumps in various parts of the thigh and leg, and by different methods. Although the deductions are necessarily imperfect and want that scientific accuracy that is desirable, still, considering the large number of cases, they are worthy of record.

AVERAGE PERIODS OF HEALING AND NON-HEALING OF AMPUTATION WOUNDS OF THIGH AND LEG.

Region and Method.	Thigh.				Leg.			
	Healed.		Not healed.		Healed.		Not healed.	
	No.	Av. No. months.	No.	Av. No. months.	No.	Av. No. months.	No.	Av. No. months.
Upper third.								
Antero-posterior flaps	1	7	3	8⅓	14	11 1/14	9	9⅓
Circular	4	11	1	8	25	11½	5	7½
Posterior flap	–	–	–	–	9	10⅓	5	10⅓
Upper and middle third.								
Antero-posterior flaps	6	9⅔	6	10	11	11 1/11	–	–
Circular	11	9⅞	2	8	15	10	2	6½
Posterior flap	–	–	–	–	9	9⅘	5	10
Middle third.								
Antero-posterior flaps	15	9 5/14	11	11 2/11	6	9⅘	1	10
Circular	9	9	4	9¼	9	10⅞	–	–
Posterior flap	–	–	–	–	7	10⅘	–	–
Middle and lower third.								
Antero-posterior flaps	12	11⅓	14	9⅞	14	10⅐	3	10⅔
Circular	9	9⅞	5	12⅔	19	13 1/19	7	12⅔
Posterior flap	–	–	–	–	3	10⅔	–	–
Lower third.								
Antero-posterior flaps	22	9	4	10½	22	9½	4	10¾
Circular	9	11⅞	1	13	18	11⅙	6	13½
Posterior flap	–	–	–	–	2	13	–	–

In regard to retracted flaps, so frequently noticed, Surgeon Hodgen makes some practical observations.

Surgeon Hodgen on treatment of retracted flaps.

He states that he "has observed a great number of cases of retracted flaps, following almost every variety of amputation, and given the subject some study. Most of them having been transported in ambulances, army wagons, railroad cars, and steamboats, were so often disturbed that there was little chance for a speedy union, and every possible facility offered for retraction of the soft parts, and the protrusion of bones. Amputations are performed during anæsthesia. The muscular tissue, which forms a larger part than any other element of the covering of the bones after amputation, is completely relaxed, and the dressing is

performed before the anæsthetic influence passes off; and when it does pass off, the muscles, resuming their original tonicity and irritability, contract, thus retracting the flaps, and either forcing the bone between the flaps or so firmly against them that ulceration rapidly follows, and the bone protrudes. Another cause is the manner of dressing stumps; thus, strips of adhesive plaster are heated and applied, one end on one surface of the limb, and the flap is drawn by this strip, which is carried firmly over the end of the stump, and the remaining end fixed tightly to the highest possible point upon the opposite surface of the limb, and so on, one after another, until a sufficient number of strips is applied to hold the lips of the wound together. It is apparent to any thinking man that these freshly cut surfaces are pressed tightly against the bone, and this is favorable to ulceration. Perhaps the most frequent cause of protruding bones is careless handling in applying dressings after the first dressing. The surgeon observes a limb requires dressing, for the bandages are saturated with pus. The bandages are removed, and perhaps also the adhesive strips, without having the parts properly supported by a competent assistant, so that newly formed attachments are broken up and the flaps fall asunder, allowing the bones to protrude." He recommends a method of treatment which he has followed with success, namely, extension of the retracting flaps by adhesive strips with a weight.

His rule is — when flaps are to unite by granulation, apply extension; when the bones protrude, apply extension; and when the cicatrix is tense and firm and slow to heal, apply extension. Never saw off protruding bones in these cases.

XI.

ADAPTATION OF COMPENSATIVE APPLIANCES.

In the adaptation of an artificial limb to the stump we have the final results of amputation in the lower extremity. Second only in importance to the life of the individual is the value of the stump for compensative appliances. The great aim of the surgeon now is, when the first question is answered and the safety of the patient is duly considered, at what point and by what method shall amputation be performed to secure a stump most favorable to the application of the best form of artificial limb. We have no longer the rich and poor man's stump; these artificial aids are now brought within the means of every man; the poorest soldier and sailor, through the wise munificence of government,

Artificial limbs.

are entitled to all the benefits which art can bestow in remedying the physical defects and deformities resulting from war. Even in civil life the poorest person, in anticipation of the charities of the benevolent, or his own providence and success in business, may demand that his limb shall be so amputated as to give him a stump adapted to the best artificial appliance.

Question to be answered by mechanical surgeon.

The question here proposed is to be answered, not by the operating surgeon, but by the skilled and scientific mechanical surgeon. It is his province to deal with the stump after it has passed from the hands of the operator, and to test its substantial merits as a means of locomotion.

AMPUTATIONS

AT THE

ANKLE JOINT IN MILITARY SURGERY.

BY

STEPHEN SMITH, M. D.

AMPUTATIONS AT THE ANKLE JOINT.

AMPUTATION at the ankle joint seems to have been a comparatively infrequent operation during the late war. In a total of 9,705 amputations, but 67 ankle-joint amputations have as yet been fully ascertained at the Surgeon-General's office. The record is, however, stated to be far from complete. Whatever may prove to be the total number of these operations, we are satisfied that ankle-joint amputations, by any of the recognized methods, were not regarded with favor by the surgeons of either the Federal or insurgent armies, at the close of the war. On a very extensive personal inquiry of army surgeons of large experience, there was found to be great unanimity of opinion in the total rejection of these operations from military surgery.

Frequency of the operation.

At the commencement of the war, amputation at the ankle joint was considered a legitimate procedure in civil practice. In some one of the several methods of operation it was almost universally regarded not only as free from danger as any amputation in that vicinity, but as yielding admirable results as respects the future usefulness of the limb. So much importance was attached to this amputation at that time that one of the oldest and most experienced army surgeons, C. S. Tripler, instructed the surgeons of the division of the army of which he was then medical director (the Army of the Potomac),to amputate at the ankle joint by Pirogoff's method in preference to amputation through the leg, when practicable.[1]

Its estimate in civil practice.

The objections of army surgeons to ankle-joint amputations are various. In the experience of some, sloughing of the flap is the chief source of mischief; others allege that extensive suppuration, or necrosis, generally follow, necessitating reamputation; while a few did not regard the stump as the most serviceable, and rejected it without trial. Considering the importance which civil surgeons generally attach to these operations, both on account of their comparative safety and the value of the stump for future usefulness, it becomes a matter of considerable

Objections to this operation.

[1] Consult Tripler's order.

importance to determine on what grounds the unfavorable opinion of army surgeons is based, and what should be the status of ankle-joint amputations in military surgery.

It must be observed, *in limine*, that amputation at the ankle joint is always an alternative operation. It is selected in preference to an amputation at a point higher up in the limb. It should also be added that it is an operation of expediency. It is not a dernier ressort. If it fails of success the surgeon may still, with rare exceptions, perform the alternative amputation through the leg with the prospect of as favorable results as when the latter is the first operation.

An operation of expediency.

In determining the value of ankle-joint amputations, therefore, the following questions naturally arise for our consideration: —

I. The comparative success of this amputation.
   (*a.*) As regards mortality.
   (*b.*) As regards the necessity of reamputation.
   (*c.*) As regards the comparative frequency of sloughing, necrosis, etc.

II. The comparative serviceableness of the resulting stump.
   (*a.*) As regards the ability for unaided locomotion.
   (*b.*) As regards the adaptation of the stump for an artificial limb.

I.

COMPARATIVE SUCCESS OF ANKLE-JOINT AMPUTATIONS.

(*a.*) *Comparative Mortality.* — From the Surgeon-General's Report[1] we learn that in a total of 67 amputations at the ankle joint, 9 proved fatal, and 58 recovered. This statement gives a mortality in this operation of 13.43 per cent. From the same source it appears that in 2,348 amputations of the leg, 611 proved fatal, and 1,737 recovered, being a mortality of 26.02 per cent. Again, the total amputations of the lower extremities, including the toes, partial amputations of the foot, etc., were 5,058, as reported to the Surgeon-General, and of this number 34.55 per cent. proved fatal.

Comparative success of ankle-joint amputation.

The results of amputation in the British army during the Crimean war do not differ materially from those given above. Amputation at the ankle joint proved fatal in about 18 per cent. of the cases operated upon, while amputations of the leg gave a mortality of 36 per cent.[2]

[1] Circular No. 6, Surgeon-General's office.

[2] *Medical and Surgical History of the British Army*, etc.

The surgical records of the insurgent armies furnish some collateral evidence. A consolidated table of amputations from June 1, 1862, to February 1, 1864, is published,[1] from which it appears that ankle-joint amputations were fatal in 20 per cent., and amputations of the leg were fatal in 27 per cent. of the cases operated upon.

From these statistics it appears that amputation at the ankle joint is 50 per cent. less fatal than the alternative amputation through the leg. Compared with the mortality after the total amputations of the lower extremity, including the most trivial, it is but a little more than one third as fatal. If we were to decide the merits of this operation, then, by its comparative fatality, or by the dangers to life which it involves, we should give it the preference, unhesitatingly, over all other forms of amputation of the leg.

But the absolute value of an amputation cannot be decided alone by its mortality. We have to consider, also, —

(*b.*) *The Comparative Frequency of Reamputation after Amputations at the Ankle Joint.* — It is difficult to determine with any considerable degree of accuracy the frequency of reamputation in any given class of cases. We are able, however, to arrive at approximative results, which indicate very clearly how in general the question is to be decided. In 31 cases of ankle-joint amputation, 4 required reamputation, or about 12.9 per cent.; in 65 amputations of the lower third of the leg, reamputation was required 6 times, or in about 9.2 per cent. of the cases.

Comparative frequency of reamputation.

It is evident from these facts that reamputation after ankle-joint amputations was more frequent than after amputations in the leg. In examining as to the causes which led to reamputation we find that in ankle-joint amputations it was performed once on account of retraction of the flaps, and three times on account of sloughing and necrosis. In amputations in the lower third of the leg reamputation was practiced five times on account of sloughing and necrosis; one case cause unknown.

(*c.*) *Comparative Frequency of Sloughing and Necrosis.* — Sloughing of the flap after Syme's amputation, and necrosis of the adapted portion of the calcaneum after Pirogoff's amputation, are alleged to be the chief sources of failure after ankle-joint amputations. The following collection of cases gives a total of 23 ankle-joint amputations by Syme's method, and

Frequency of sloughing and necrosis.

[1] *A Manual of Military Surgery*, etc., by J. Julian Chisholm, M. D., third edition, Columbia, S. C., 1864.

10 by Pirogoff's method. Of the 23 cases of Syme's amputation, 4 are reported to have been followed by sloughing of the flaps, and 3 by necrosis. In other words, 7 in 23 cases were followed by sloughing and necrosis, or 30.4 per cent. Of the 10 cases of Pirogoff's amputation, 2 are reported to have been followed by necrosis, in one case the os calcis necrosed, and in one the posterior part of the lower extremity of the tibia was involved. It is noticeable that in two cases of sloughing after Syme's operation the stumps healed and ultimately became serviceable.

It cannot be alleged, however, that the comparative difference between these two operations is sufficient to decide the question as to the point of election. If ankle-joint amputations present any very considerable advantages in other respects over leg amputations, no prudent surgeon would regard this slightly greater liability to sloughing and necrosis as a sufficient reason why he should be deterred from selecting the former.

Before determining the question, we must consider the comparative value of the stumps resulting from these different operations: —

II.

COMPARATIVE SERVICEABLENESS OF THE RESULTING STUMP.

Serviceableness of stump.

(*a.*) *As regards Locomotion.* — Ankle-joint amputations differ from amputations in the leg in this essential particular, namely: in the former the support is taken directly upon the extremity of the stump, and in the latter upon the sides of the limb. In model stumps of each class it will be found that the one which takes direct support upon the extremity is not only capable of enduring a much larger degree of service, but the person suffers far less inconvenience. Direct pressure upon the heel flap may be endured as long in Syme's stump as similar pressure upon the natural heel. And the same is true of stumps following Pirogoff's method. Patients with these stumps have frequently been known to walk successive days twenty and thirty miles with only the simple covering or protection of the heel of a common shoe or boot. Mr. Syme stated in a clinical lecture that "Patients who had suffered the operation, were able to stand, walk, and even run, without any covering or protection of the stump; and a gentleman present, having had his attention accidentally directed, a few days before, to some boys who were amusing themselves on a slide in the street, discovered that one of them had undergone amputation at the ankle joint." Professor Van Buren, of New York,

recently met at his clinic the third person on whom Mr. Syme performed this operation, sixteen years before, who stated that he had walked thirty miles in a day without inconvenience from his stump. These are by no means exceptional cases. Surgeons who have been accustomed to meet with the results of this operation most frequently, uniformly testify to the ease with which patients betake themselves to the stump with only such covering as they can rudely adjust. Of the stumps left by Syme's and Pirogoff's operation, the latter has the greater length, and thus requires less compensation.

Amputations through the leg, at whatever point, and however skillfully performed, never furnish stumps which take direct support. The limb is useless for locomotion by any simple means of compensation; it is only when an artificial limb is accurately and skillfully adjusted that it serves the purpose of even simple progression.

Amputation of leg does not give direct support.

Again, in amputation at the ankle joint the patient retains power over the muscles of the calf which are essential to the act of running. It is extremely rare that a patient who has suffered amputation of the leg can make even the pretense of running upon his artificial limb. The muscles, especially of the calf, have shrunken from disuse, and progressive, permanent atrophy of the parts below the knee ensues. In ankle-joint amputations, however, the tendons of all the muscles employed in locomotion retain their former, or acquire new attachments, and are immediately and constantly exercised in the movements of the limb. It is true this movement of the muscles is more limited than in the normal limb, but it is nevertheless sufficiently great to preserve much of their activity, and consequently their nutrition is but partially impaired. The importance of preserving the functions of the muscles of the leg is seen in the perfection of gait which persons with ankle-joint amputations soon acquire. They can not only run, often with great ease and facility, but they acquire the power of leaping, dancing, etc., to such perfection that their disability frequently passes unrecognized.

Patient has power over muscles of calf in ankle-joint amputations.

(*b.*) *As regards the Adaptation of the Stump for an Artificial Limb.* — As previously stated, the stump after ankle-joint amputation takes direct support upon the extremity. Mr. Quain thus speaks of the advantages of direct support, in referring to Syme's amputation: "It is free from any valid objection, and, what is more important, the result in practice has been found to be good. A person who has undergone this opera-

Adaptation of stump for an artificial limb.

tion is enabled to bear his whole weight upon the end of the stump without inconvenience ; and on this account the facility of progression is, with a proper apparatus, decidedly greater than when the amputation is performed at any higher part of the limb."

Advantages of stump at ankle.

The advantages of the ankle-joint stump over those of the leg for the adaptation of an artificial limb, are admitted by the most competent mechanical surgeons to be of the most undoubted character. In Syme's amputation the patient walks upon the end of the stump with ease and grace, can run, leap, and dance, and is capable of enduring fatigue little short of that of the sound limb. We speak now of successful cases. No results at all comparable with this are attainable with any form of stump above the ankle.

This review of the comparative merits of ankle-joint and leg amputations as exhibited by statistical evidence authorizes the following conclusions : —

Conclusions.

1. Ankle-joint amputations are fifty per cent. less fatal than leg amputations.

2. Ankle-joint amputations are three per cent. more liable to be followed by reamputation than leg amputations.

3. The stumps left after ankle-joint amputations are far more serviceable than those resulting from leg amputation for unassisted locomotion.

4. An artificial limb can be far more usefully applied to an ankle-joint than to a leg stump.

Experience of late war.

It may be stated in general terms that the experience of the late war has established the fact that ankle-joint amputations are less fatal than leg amputations, but that sloughing and necrosis are more likely to occur in the former than in the latter ; that the resulting stump in ankle-joint amputations is much more favorable for unaided or aided progression than in leg amputations. The correct inference from these conclusions is that ankle-joint amputations should be recognized as occupying an important place among the legitimate operations of military surgery.

Causes of failure.

It remains to consider the causes of failure in ankle-joint amputations as illustrated in this collection of cases, the remedial measures adapted to prevent or mitigate such causes, and, finally, the comparative value of the methods of operation proposed by Syme and Pirogoff.

CAUSES OF FAILURE IN ANKLE-JOINT AMPUTATIONS.

The striking difference in the success of ankle-joint amputations in civil practice from that in military practice, depends upon causes not difficult to determine and appreciate.

Surgeon David P. Smith, United States Vols., who has had a large experience, and is a warm advocate of the operation, says: —

"When done in our army for gunshot wound, the results have not, by any means, been uniformly successful. It appears, however, that the failures can hardly with justice be attributed to the form of operation. From much conversation with army surgeons upon this topic, and from no inconsiderable personal experience, it is believed, first, that the operations have been generally too long delayed, and at last done when, from the undermining of tissues by the burrowing of pus, there could be no reasonable hope of success; and, secondly, that the manual performance was faulty in the extreme."

Surgeon David P. Smith on causes of failure.

He illustrates the failure of the operation from the first cause by his own experience: —

"The four cases of ankle-joint amputation occurring at Fairfax Seminary General Hospital, were performed upon wounded removed at a late date from the disastrous field of the second Bull Run battle, where they had undergone much privation and hardship. The tissues were undermined with pus. Had I not witnessed Mr. Syme's own practice, and heard him detail his experience of constant success under the most adverse circumstances, I should have preferred amputation in the continuity of the leg in these cases, so great was the suppuration about the ankle above the point of section. Mr. Syme's procedure was strictly followed in all four cases.

"One recovered, and left the hospital with a good firm stump.

"One, apparently the most suitable of all for this operative procedure, succumbed to pyæmia. In this case no section of bone was made, even the malleoli being suffered to remain.

"Two, on account of sloughing of flap and protrusion of bone, were obliged to submit to amputation of the leg."

The various causes of failure of this operation may be considered under the following heads: —

I. Sloughing of the Flaps. — In the early history of ankle-joint amputations, especially by the method of Syme, sloughing of the flaps was a frequent accident. Many surgeons were led to discard the operation altogether after repeated failures from this complication. Experience proves, however, that

Sloughing of flaps.

sloughing cannot be regarded as a necessary or even a frequent result of this operation. It occurred but four times in twenty-three cases as we have already shown.

There are apparently two principal causes of sloughing of the flaps, namely: (*a.*) *Contusion of the soft parts entering into the flaps;* (*b.*) *Destruction of the nutritious arteries of the flap in the operation.*

Contusion of soft parts.

(*a.*) *Contusion of the Soft Parts.* — It not unfrequently happens that in the accident that caused the injury for which amputation is performed, there is a much larger destruction of the soft parts than at first appears. Especially is this true of railroad injuries, gunshot wounds, etc. The sudden and terrible violence of the impinging body not only destroys the vitality of the part which it encounters by direct contact, but the same destructive effects are manifested in contiguous tissues after several days over a surface often surprisingly extensive. And this deception is rendered the more complete by the apparent accuracy with which we may at first limit the destroyed parts. The line of demarcation seems well defined by the discoloration which borders the upper limit of the lesion of tissues. But within a day or two the fallacy of this observation becomes unpleasantly apparent. Parts that at first were believed to be uninjured become cold, the purple discoloration of incipient gangrene extends, and the slough that forms proves that the skin and subjacent tissues were devitalized by the shock far beyond the bounds that had been set.

Liability to amputate in injured parts.

Hence, it not unfrequently happens that the surgeon called to perform an immediate amputation after railroad and gunshot injuries, of the severe class, is deceived as to the extent of the actual destruction of the vitality of the soft parts, and, in his anxiety to save as much of the limb as possible, makes the whole or considerable portions of the flaps of tissues which are already destroyed and must slough. This result is often seen in civil practice after severe railroad injuries, and the same is true of military practice, especially where the injury has been inflicted by a missile of large size, as a cannon-ball, grape-shot, etc.

Heel most exposed to injury.

In no part of the lower extremity are we as liable to meet with this accident as at the heel. The crushing of the foot by railroad cars, or by missiles used in war, not unfrequently impairs the vitality of the soft parts about the heel and ankle to such a degree, that when they are subjected to the necessary bruising of an amputation, sloughing to a given extent ensues.

It is evidently no fault of the operation that in such a case sloughing of the flap occurs. Sloughing doubtless to the same extent would follow any form of amputation which involved tissues similarly injured. The error is in the judgment of the surgeon; amputation should have been originally performed where it was subsequently. But this error is not always reprehensible, for the most experienced and judicious surgeon cannot foresee always the extent of the injury. Where there is a rational doubt, the facts embodied in this paper will, we think, authorize the operator to decide in favor of ankle-joint amputation, as in general preferable to leg amputation, and holding the latter in reserve.

There is a practical point, illustrated by this collection of cases, bearing upon the question of amputation when the soft parts about the heel have suffered severe contusion and laceration, which deserves the most serious consideration. If the tissues of the heel have been destroyed, the surgeon should not at once decide that this precludes amputation at the ankle joint, as might be inferred from the preceding remarks. Important as are the tissues of the heel for the covering of the stump where it is to take direct pressure, it is nevertheless true that the tissues of the sides of the ankle and the dorsum of the foot will soon become sufficiently dense to bear readily the weight of the body. If therefore the operator is convinced that on general principles an ankle-joint amputation is preferable to a leg amputation, he should consider well before he rejects the former, if it is not possible to secure sufficient flap tissue around the ankle.

Possibility of saving flaps.

The following case illustrates this point: —

Case I. *Wound of the Ankle by the Fragment of a Shell; Extensive Destruction of the Soft Parts; Amputation by Lateral Flaps; Sloughing; Final Cicatrization and a Useful Stump.* — C. D. was wounded June 24, 1864, by the fragment of a shell, which struck the sole of the foot just anterior to the heel, lacerating the soft parts extensively, and injuring the tarsal and metatarsal bones. He was removed to the Mower U. S. General Hospital, where amputation was performed on the third day by Acting Assistant-Surgeon W. P. Moon. Owing to the laceration of the soft parts, a complete posterior flap could not be made from the heel. Flaps were, therefore, dissected from the sides of the ankle and foot, and particularly from the sole on the external part.

Extensive destruction of soft parts; lateral flaps.

For a few days the case progressed favorably; sloughing then occurred to a small extent, and finally a small fragment of bone separated; abscesses also formed, one being of considerable size. The

wound at length completely cicatrized, and the stump assumed a good shape, though it was somewhat tender.

Case II. *Wound of the Ankle Joint by a Spiral Case-shot; Destruction of the Heel; Formation of Lateral Flaps; Recovery with a Useful Limb.* — A. L. T., private, 20th Regiment Massachusetts Vols., was wounded at Fredericksburg, Va., May 2, 1863, by a spiral case-shot which passed through the ankle joint, destroying the articulation and the soft parts about the heel. Amputation was performed about four hours after the receipt of the injury. Notwithstanding the destruction of the heel, it was decided to amputate at the ankle joint, and make the flaps from such uninjured tissues in the neighborhood as could be brought to cover the stump. A sufficient amount of tissue was accordingly dissected from the lateral parts of the ankle to cover the stump, and disarticulation was performed. With the exception of several abscesses which formed from time to time, the wound progressed favorably, and at the end of three months cicatrization was complete, and he could bear his weight upon the stump. The only unpleasant sensation experienced was a prickling. At the end of five months an artificial limb was applied by Hudson, of New York, which enabled him to walk "with ease and comfort."

Lateral flaps.

Case III. *Extensive Laceration of the Tissues of Foot and Heel by Fragment of a Shell; Amputation at Ankle Joint with Lateral Flaps; Recovery with a Useful Limb.* — H. H. C., private, 100th Regiment New York Vols., was wounded at Drury's Bluff, Va., in May, 1864, by the fragment of a shell striking the left foot. The soft parts of the foot and heel were so extensively lacerated as to preclude the formation of a flap from the heel, if amputation were performed at the ankle joint. It was, therefore, determined to amputate at the ankle joint, with flaps formed from the sides of the ankle.

Lateral flaps

The operation was performed by Surgeon Kettinger, United States Army, and flaps were made from the lateral aspects of the ankle. The case progressed favorably, although the patient suffered at the same time an amputation of the other foot by Chopart's method. The cicatrix became firm and healthy, and the patient could bear his weight upon it with comparative ease. An artificial limb was subsequently applied by Hudson, of New York, with the most satisfactory results.

Equally good results may be obtained by taking the principal flap from the dorsum of the foot, as is seen in the following case: —

Case IV. *Amputation of the Ankle Joint for an Old Railroad Injury; Principal Flap taken from the Dorsum of the Foot on Account of Ulceration of the Tissues of the Heel; Sloughing of the Extremity of the Flap; Final Cicatrization of Wound; Useful Stump.* — This case was

treated in Bellevue Hospital, and the history is taken from its records: "B. T. K. —— Regiment New York Vols., was admitted to Bellevue Hospital in March, 1864. About two years before, his left foot was caught under a rail-car wheel and severely crushed. He had on the foot a very stout boot, with an unusually thick and firm sole, which saved it from being entirely destroyed. The wheel traversed the foot from the heel to the toes, passing diagonally along the dorsum from the external malleolus to the great toe, fracturing the tarsal, metatarsal, and phalangeal bones in its course. An attempt was made to save the foot. Suppuration was established throughout the foot, with sloughing of the contused integument. Fragments of bone were removed, involving the tarsal and metatarsal bones, but the wound both on the dorsum and palmar surfaces finally completely cicatrized, and he was discharged. Flap from dorsum of foot.

"On entering Bellevue Hospital, about two years from the time of the injury, the foot was so completely crippled that he was unable to walk except with crutches. It was so twisted upon itself by the cicatrix on the sole as to assume the position of a talipes varus. An ulcer existed upon the heel, and the tissues of this region were for the most part cicatricial. The cicatrix upon the dorsum was not very firm or adherent, except over the metacarpal bone of the great toe.

"Amputation at the ankle joint by any of the ordinary methods was impossible; but it was determined to make the flap from the dorsum, and take the risk of sloughing in the line of the cicatrix. The operation was performed by Dr. Stephen Smith. A sufficient flap was readily secured, which, turned backward, effectually covered the whole surface of the stump. As was feared, the extremity of the flap where the cicatrix was most dense, sloughed off, but the remainder rapidly united. The stump was moulded by adhesive strips, and assumed a very fine appearance. The patient left the hospital able to walk with comparative ease."

The following case illustrates still more strikingly the value of an ankle-joint amputation: —

CASE V. *Bony Anchylosis of Tarsal and Ankle Joints; Extreme Thickening and Degeneration of Soft Parts; Sloughing of a Portion of Anterior Flap; Successful Moulding of the Stump by Adhesive Strips; Recovery with a Well-formed and Useful Stump.* — The following history is taken from the records of Bellevue Hospital, where the case was treated: Patrick Connelly, corporal, 70th Regiment New York Vols., was wounded at Bristow's Station, Va., August 29th, 1862, by a minie-ball. The point of entrance was the posterior part of the left heel, and it was removed from beneath the integument on the dorsal face of the tarsus, having completely traversed the tarsal bones. The limb was at first condemned to immediate amputation, but subse- Moulding of stumps by adhesive strips.

quently efforts were made to save it. Suppuration soon became established throughout the tarsus, the foot, and ankle; sinuses formed in various directions, and portions of bones from time to time escaped from the various sinuses.

At the end of a year the inflammation had so far subsided that he was able to walk about on crutches. He obtained his discharge from the army, and returned to his business of a mechanic. He was able at length to bear considerable weight upon the foot, but he was finally obliged to seek more permanent relief.

On entering the hospital his foot was a large, shapeless mass, the swelling and puriform appearance extending from above the ankle to the toes. On the posterior part of the heel was the depressed cicatrix of entrance, and upon the centre of the tarsal region in front was the open extremity of a sinus which corresponded with the point of exit. There was no apparent motion at the ankle or tarsal joints. A probe passed into the sinus came in contact with uncovered bone. His general health was good.

A consultation decided in favor of amputation of the leg. The question of amputation at the ankle joint was discussed, but the soft parts were so thickened and unhealthy, that it was believed that an operation which involved such tissues would necessarily prove a failure.

Subsequently Dr. Stephen Smith amputated at the ankle joint. On incising the soft parts, they were found of the consistence and appearance of fat pork, and so thick and dense that it was impossible to turn the flaps back for the purposes of dissection. The ankle joint being fixed by bony anchylosis, it was sawn through. So thick and unyielding were the flaps, that it was found impossible to unite them, and they were left unadjusted. On the following day a slough began to form around the old sinus, which finally involved two square inches of surface. It was very soon noticeable that the infiltrated tissue began to soften and disappear, melt down apparently, and the flaps became more thin and pliable. Adhesive strips, cut very narrow, were now applied very accurately to the flaps, and the stump rapidly took a round and symmetrical form. Owing to the sloughing, a large cicatrix remained drawn somewhat across the face of the stump. This cicatrix was slow in healing, scabs forming of large size. He experienced considerable inconvenience for a time from this unhealed junction of flaps, but at length the cicatrix was perfectly formed, and he walked with ease with the heel of a boot for his support.

Dr. E. D. Hudson, of New York, applied an artificial limb to the stump, which eventually served him perfectly. He continued under observation for several months, as gate keeper at the hospital, and always expressed himself as able to do his duties with little or no inconvenience from the stump.

(*b.*) *Destruction of the Nutritious Artery of the Flap during the Operation.* — Mr. Syme remarks upon this cause of failure: "That the flap may and probably will still occasionally slough, is unhappily too true; but that this result is always owing to an error in the mode of performance, I think does not admit of any question. For as the integument, being detached from its subjacent connections, can derive nourishment only from the anastomosing vessels, it is evident that if scored crossways, instead of being separated by cutting parallel to the surface, the flap must lose its vitality." In his early practice of Syme's operation, Mr. Ferguson, of London, committed the error above alluded to, and so frequently did he meet with sloughing of the flaps that he rejected the operation altogether. Subsequently, however, he became one of its strongest advocates, stating: "In so far as I can judge, it is one of the greatest improvements in modern surgery as regards the subject of amputations." Destruction of nutritious arteries in operation.

That there is great danger of wounding the posterior tibial artery in making the principal dissection from above downward, and from before backwards, is a demonstrable fact, and there is no doubt that it is one source of failure of this operation. While we are not able to determine how frequently this accident happens, we know that among army surgeons the erroneous method of operation alluded to by Mr. Syme was occasionally practiced. We feel authorized, therefore, to attribute to this cause a certain percentage of the failures of ankle-joint amputations from sloughing of the flaps.

II. Necrosis. — It cannot be seriously alleged against Syme's amputation that the small amount of necrosis which occasionally results to the extremity of the tibia or fibula is a valid objection to its performance. It is stated to have occurred four times in twenty-three cases, and in three of these the necrosis does not seem to have interfered with the final success of the case; one was still under observation. It is extremely rare that the necrosis is of any considerable extent, or so complicates the recovery as to necessitate reamputation. Necrosis in Syme's amputation.

The opponents of Pirogoff's amputation urge the dangers of necrosis with great pertinacity, although experience decidedly disproves the correctness of their logic. Theoretically the argument is strong and almost conclusive against the operation. It is essentially a resection of bones with an attempt to obtain union by placing the fragments in simple contact. It Necrosis after Pirogoff's amputation.

cannot be denied that the section of the calcaneum does occasionally undergo necrosis, and finally separates from the flap, but it must now be considered a rare accident, and dependent rather upon the imprudence of the operator in his effort to excise the bone, than upon any intrinsic fault of the method itself. Pirogoff remarks: —

Pirogoff's remarks.

"Notwithstanding the suppuration and considerable gravitation of pus into the flap in the third case; notwithstanding the softness and fatty degeneration of the os calcis, which could be cut with the knife, in the second case; and lastly, notwithstanding the bleeding fungous excrescences which formed on the bones, also in the second case; still the remains of the os calcis united firmly with the tibia and fibula. Lastly, one of the cases, the third, proves that the exarticulation at the ankle joint after my method — at least in children and young people — may be undertaken even in cases of diseased ankle joint, provided disorganization has not extended too far over the soft parts about the articulation. In the boy in the second case, I found pus in the capsule during the operation, the cartilages softened and decayed, the ends of the bones also softened and in a state of fatty degeneration, yet the result was most successful."

Mr. Busk, of London, says: —

Mr. Busk's remarks.

"Some have feared that the section left of the calcaneum would not readily unite with the extremity of the tibia; but this fear is groundless. In the last operation performed by Mr. Tudor, union was found to be quite firm on the twelfth day. . . . . In my first case the man could support his whole weight on the stump within a fortnight."

Mr. Croft, of the *Dreadnought* hospital ship, London, gives the experience of the surgeons of that ship in six cases, as follows: —

Mr. Croft's experience.

"Six times the operation has been performed, and in four instances with most perfect success; but in the two remaining death removed the subjects of operation before cure was completed — in the first instance by granular disease of the kidneys, and in the second instance by secondary deposits of pus in various joints. In two of the six cases in which cure was completed, the operation was performed for the removal of scrofulous disease of the articulation between the tarsal bones, and in the two others the operation was for frost-bite of the anterior part of the foot. Progress towards health was marked by suppuration along the tendons of the tibialis anticus and posticus, and the peroneal tendons in each of the cases, but not by exfoliation of bone. The posterior part of the os calcis was united firmly with the

tibia, generally in about three weeks; but in one instance — the last in which the operation was performed — union was good at the end of twelve days."

He thus expresses his confidence in the union of the bones under the most unfavorable conditions: —

"Although the os calcis may be diseased at and about its articulation in instances of scrofulous disease of the joints of the tarsus, it is rarely that the posterior part is rendered too unhealthy to be made use of in the formation of a stump."

Hewson, of Philadelphia,[1] has operated five times, and makes the following comments, bearing upon the question of necrosis of the os calcis: —

Dr. Hewson's comments.

"In all a cure followed rapidly. In two especially, the result was least to be expected. These were the adults, one of whom was a seaman advanced in years, and who had been leading an exceedingly intemperate life; and the other a soldier, who had been wounded in a battle after long and tedious marching in pursuit of the enemy, and who was operated on four weeks after receiving his wound, in a military hospital where gangrene was prevailing to a very great extent at the time. How much the firm and speedy union of the bones in all these cases was the result of the expedient resorted to, namely, the strip of adhesive plaster and the weight, to prevent the contraction of the muscles attached to the tendo Achillis, is a question which we are not prepared to answer. The possibility of such a union not taking place, has been the only theoretical objection apparently of any importance advanced against the operation. But how far such an objection has been realized in the experience of others we have not been able to ascertain. Our own experience certainly points to its being of little, if any, value. For surely there could not be found two more unpromising cases for any operation than those of the adults here reported, and it is against the operation in adults especially that this objection would seem to have greatest force. The very perfect character of the union which took place between the bones in Bowers' case, as is to be seen in the specimen which we had the good fortune to obtain after his death, furnishes as strong a refutation as a single instance could of this theoretical objection."

Of the ten cases of amputation at the ankle joint by Pirogoff's method, reported in the following tables, but one was attended with necrosis of sufficient amount to necessitate reamputation.

[1] The *American Journal of Medical Sciences*, July, 1864.

The patient was a Confederate soldier, and the case is reported by James M. Holloway, M. D., Professor of Anatomy, Louisville, Ky.[1]

Reamputation for necrosis in Pirogoff's amputation.

CASE VI. *Pirogoff's Amputation at the Ankle Joint; Necrosis of the Section of the Os Calcis and of the Tibia; Reamputation of Leg.* — A. B., soldier, was wounded at Chattanooga, Tenn., in 1863. Amputation at the ankle joint by Pirogoff's method was performed a few days after the injury. The reporter first saw the case in January, 1864. The flaps had united, but a number of sinuses communicated with the coaptated surfaces of the os calcis and tibia, at the bottom of which denuded bone could be felt upon the introduction of the probe. In addition to these, other sinuses situated on the lateral aspects of the lower third of the leg, communicated with the sheaths of the tendons. These latter, so far as could be learned from the patient, appeared subsequently to those leading to the carious bones. The integuments overlying and adjacent to the diseased bone and inflamed sheaths of tendons, presented a remarkably healthy appearance; so much so that the true condition of the stump did not transpire until a more thorough examination was made, while the patient was under the influence of chloroform. Such was the complete disintegration of the os calcis and the end of the tibia that amputation of the leg was found to be necessary.

The following cases illustrate most forcibly the fact that the segment of the os calcis will become united to the tibia under the most unfavorable circumstances: —

The bone will unite under most unfavorable conditions.

CASE VII. *Wound of the Ankle Joint; Pirogoff's Amputation; Feeble Condition of Patient; Attack of Erysipelas; Symptoms of Pyæmia; Convalescence; Recovery with a Useful Limb.*[2] — Lieutenant W. C. W., Co. I, 5th Michigan Cav., was wounded April 1st, 1865, at the battle of Five Forks, by a conoidal musket-ball, which passed through his left ankle joint. He was immediately carried to the hospital at City Point, and amputation at the ankle was performed on the same day by Surgeon St. Clair, 5th Michigan Cavalry; the articulating surfaces of the tibia and calcaneum were removed, and the cut surfaces were brought into apposition. On April 16th, 1865, the patient was transferred to Armory Square Hospital, at Washington. On admission he was in a feeble condition. An erysipelatous blush extended above the knee on the injured side, an abscess had formed in the lower part of the leg, and no union of the flap had taken place. With the employment of stimulants and nutritious diet, with emollient applica-

[1] *Am. Journal Medical Sciences*, January, 1866.

[2] Circular No. 6, Surgeon-General's office.

tions to the limb, there was a gradual improvement, until April 28th, 1865, when symptoms of pyæmic infection supervened. Rapidly recurring chills, an icteroid coloration of the skin and conjunctiva, anorexia, and a frequent feeble pulse, suggested the gravest prognosis. Energetic treatment was adopted. An ounce of brandy was given every two hours, and quinia, sesquichloride of iron, and beef tea were freely administered. On May 6th, the grave symptoms began to subside, and, by the end of the month, the patient was fairly convalescent. On June 26th, he was pronounced well. The os calcis had firmly united to the tibia, and there was a good solid stump.

CASE VIII. *Amputation at the Ankle Joint by Pirogoff's Method on the Battle-field at Malvern Hill; Patient taken Prisoner, and conveyed in an Army Wagon to Richmond; neglected and exposed to Great Hardships for Several Days; exchanged, and conveyed to City Point without Care or Support in extremely Hot Weather; transported to Fortress Monroe before Proper Dressings were applied; Perfect Union of Hard and Soft Parts without the Slightest Necrosis or Sloughing; Useful Limb.* — H. B., private, 5th New York Art., was wounded by a shell at the battle of Malvern Hill, July 1, 1862. The injury was inflicted principally in the metatarsal and tarsal regions, producing a compound comminuted fracture of the bones of the foot, with the exception of the astragalus and calcaneum. Chloroform was administered, and amputation by Pirogoff's method performed. He was immediately after taken prisoner, and placed in an army wagon and conveyed to Richmond. The weather was extremely hot, and he had no means of supporting or protecting the stump. He remained at Richmond several days, during which he was crowded together with other prisoners, without care, his limb remaining undressed. He was finally exchanged and conveyed to City Point, a distance of twenty-six miles, most of the distance on the railroad, the remainder in an ambulance, but the entire distance he was compelled to take his chances with the crowd. From City Point he was conveyed to Fortress Monroe, where he had the first proper dressings applied. No sloughing or necrosis occurred; the bone united promptly, and the flaps adhered as if union had taken place by first intention. He came under observation at Central Park Hospital several months after, when the stump was in the most perfect condition. It had the appearance of having healed by first intention, throughout. He bore his weight upon it, walked easily with a cane, but complained of slight tenderness. An artificial limb was applied by Hudson, of New York, and he was discharged in a condition to be able to follow almost any ordinary employment.

A second unfavorable case terminating in a good recovery.

The two following cases were reported by Adinell Hewson, M. D., surgeon to the Pennsylvania Hospital:[1] —

[1] *Am. Jour. Med. Sci.*, July, 1864.

CASE IX. *Foot crushed by the Recoil of a Gun-carriage; Attempt to save the Foot; Great Distortion of Foot; Amputation at the Ankle Joint by Pirogoff's Method; Prompt Union of Bone; Recovery with a Useful Limb.* — Tom Bowers, a tall, thin, but well-formed seaman, aged forty-eight years, applied for admission to the Pennsylvania Hospital, on the 3d of March, 1863, on account of distortion of his right foot, the result of an injury received on board of one of the Mississippi gunboats in the attack on Vicksburg, in the month of June previous. The foot had then been crushed by the recoil of a gun-carriage, and the bones of the metatarsus had evidently — according to the patient's account — been much comminuted, with great contusion of soft parts, but no great amount of laceration of integument. Attempts had, therefore, been made to save the foot. Extensive phlegmonous inflammation ensued, and extended up the leg, which bore the marks of the free incisions which had been made for the escape of the pus.

Hewson's case.

The foot itself was distorted by the conglomeration of the bones, through the callus thrown out for their repair, and by a large mass of cicatricial tissue on the plantar surface, all of which combined to draw the toes down and prevent the patient walking on the sole. It was thus only by a very forced elevation of the forepart of the foot, and throwing the whole weight on the back of the heel, that he could get along on the limb. For this deformity he applied at the hospital, desiring to have the leg amputated. It was evident that a partial amputation of the foot was the only remedy for him. The cicatricial mass on the sole would not allow of a Lisfranc tarso-metatarsal disarticulation, or of a Chopart inter-tarsal. It was, therefore, determined to make a Pirogoff amputation. . . . . Some symptoms of delirium tremens manifested themselves on the following day, and these were soon developed into a well-defined attack of that disease. The operation was consequently delayed until the 28th of the month (March), when it was performed. . . . . Owing to the rigidity of all the tissues of the foot, considerable difficulty was experienced in effecting sufficient dislocation at the ankle to saw off the os calcis at the proper angle. Indeed, this was found impossible without injuring the soft parts. The bone had consequently to be broken after it was partly sawn through. No dressing was applied over the wound. The stump was put in a fracture-box, and the weight of a brick, about four and one half pounds, was applied by means of a long and broad strip of adhesive plaster on the back of the leg to overcome all tendency to displacement of the os calcis, by contractions of the muscles attached to the tendo Achillis. The healing took place very slowly. Still the patient was well enough to be discharged on the 25th of May, eleven weeks after the operation. The os calcis was noted to be firm to the tibia on the twenty-sixth day.

CASE X. *Wound of the Ankle Joint; Suppuration in the Joint;*

Amputation by Pirogoff's Method on the Twenty-eighth Day; Subsequent Necrosis of Fibula; Rapid Union of Os Calcis and Tibia; Recovery with a Useful Limb. — O. C., aged twenty, private, 7th Wisconsin Regiment, was wounded on the first day of the battle of Gettysburg (July 1, 1863), by a bullet in the right foot. From the battle-field he was sent to the United States Military Hospital, Philadelphia, where he arrived on the 6th. The wound did not appear at first to be a serious one, and our attention was not called to it until some time after his admission, when the foot and ankle had become very much swollen and inflamed. On probing the wound it was found that the ball had passed through the astragalus, and must have consequently implicated the ankle joint. It was, therefore, determined to amputate the foot, and, as the tissues of the heel appeared sound, it was decided to attempt a Pirogoff, which was done on the 28th of the month (July). On opening the joint it was ascertained that the malleoli had both become considerably denuded by the suppuration which had been going on in the joint, so that it became necessary to remove the ends of both the tibia and fibula an inch above the joint. The denudation of the bones led us to form a rather unfavorable prognosis for the operation. The inflamed condition of the tissues, especially of those composing the anterior flap, caused delay in the process of union, which took place, however, throughout by granulations, and the portion of os calcis was found to be firmly adherent to the tibia on the twenty-eighth day after the operation. When the cicatrization of a greater part of the flaps had been accomplished, it was discovered that two suppurating points, one quite on the front of the leg, and the other behind the line of the fibula, communicated by sinuses with a large piece of necrosed bone evidently belonging to the fibula, and which had pushed the os calcis somewhat to the inside before it had become firm to the tibia. These sinuses were dilated by sponge tent, and this portion of bone detached without even disturbing in the least the union between the tibia and os calcis. The patient is now just beginning to throw his weight on the stump, which has been entirely healed for about a month. He ran with ease on the end of the stump before the members of the college at the meeting at which this communication was made."

III. SENSITIVENESS OF STUMP. — But it is frequently alleged that the stump after ankle joint amputations is very liable to be tender, and will not tolerate direct pressure. In this case we not only lose all the advantages claimed for direct support, but from the shape of the stump it is difficult to obtain sufficient lateral support of the limb to render the artificial appliance useful. This objection cannot, however, be founded on a very large experience. In the thirty-one cases in the accompanying tables, tenderness of the stump of a degree sufficient to interfere with the application of an artificial limb is not once men-

Sensitiveness of stump.

tioned. Hewson, of Philadelphia, speaking of the ease with which patients walk who have Pirogoff's stump, says: —

Hewson's experience.

"No such results as these have ever been obtained from the Syme operation — for not more than one half of the cases which have applied to Mr. Palmer for artificial limbs have been able to bear any pressure whatever on the end of the stump, and that a long time after they were entirely healed. The only case of a Syme amputation of which we have had the opportunity of seeing the results was unable to bear his weight on it a year after it was made."

This statement is in direct opposition to the experience of surgeons of large experience. Fergusson, of London, who has repeatedly operated by this method, says: —

Fergusson's opinion.

"In so far as I can judge, it is one of the greatest improvements in modern surgery as regards the subject of amputation."

Quain, of London, says it is —

Quain's opinion.

"Free from any valid objection, and what is more important, the result in practice has been found to be good. A person who has undergone this operation is enabled to bear his whole weight upon the end of the stump without inconvenience; and, on this account, the facility of progression is, with a proper apparatus, decidedly greater than when the amputation is performed at any higher part of the limb."

Erichsen, of London, confirms the above estimate of Syme's amputation. He says it —

Erichsen's opinion.

"Constitutes one of the greatest improvements of recent date in operative surgery, as by its performance amputation of the leg may often be avoided, and the patient being left with an exceedingly useful stump, the covering of which being ingeniously taken from the heel, constitutes an excellent basis of support."

But the strongest and most important testimony as to the entire

Opinion of Dr. Hudson of New York.

serviceableness of Syme's stump is given by Hudson, of New York, who states that in fifty cases to which he has applied artificial limbs he has not met with a single instance where the stump did not, after proper preparatory treatment, take the direct pressure without inconvenience, and invariably give a most happy result. This treatment consisted in removing scabs from the cicatrix, healing superficial indolent ulcers, etc. We need only add that in a large collection of cases from civil practice

but one Syme's stump was found sensitive. It is very important that the surgeon should examine the cicatrix occasionally after the cure seems to be complete, to insure a firm closure of the wound. If a small space is left over which scabs form, these incrustations become so thick before the patient removes them that they take the whole pressure when the stump is placed upon the floor, and the violence is expended upon the small ulcerated surface on which they rest. I have frequently seen stumps which have been pronounced tender, found capable of sustaining the weight of the body, and enduring great fatigue when these incrustations were removed. It is the duty of the surgeon not only to remove these constantly recurring scabs, but to heal by appropriate treatment the chronic, indolent ulcer from which they spring.

Bad effects of scabs on cicatrix.

Surgeons have mistaken the early sensitiveness of the wound for a permanent disability. A certain degree of tenderness must necessarily exist for a time as the result of so considerable a wound, but as cicatrization progresses the sensitiveness generally gradually subsides, and ultimately ceases to give the patient any trouble

Sensitiveness not a sign of permanent disability.

IV. Tendency to Displacement of the Heel Flap backward by the Action of the Muscles of the Calf. — A final cause of failure is alleged to be due to the action of the muscles of the calf, which so act upon the heel, or posterior flap, as to bring the cicatrix upon the most dependent part of the stump, and expose it to injury in walking. The objection is based upon clinical experience, and this result has led to reamputation in some cases.

Displacement of heel flap backward.

We have reason to believe, however, that this posterior displacement of the flap is due to circumstances entirely within the control of the surgeon. The remedy is found in the after treatment. Displacement will never take place to an extent sufficient to interfere with complete usefulness of the stump, either in Syme's or Pirogoff's stump, when the posterior flap is well supported and proper traction is made upon the calf. Surgeons too frequently leave the flap entirely unsupported, so that even its weight displaces it. The natural tonicity of the muscles of the calf under such circumstances leads to their abnormal contraction, and hence to the permanent displacement of the flap. The following case illustrates this displacement from want of support: —

Within the control of the surgeon.

Case where there was no support.

CASE XI. *Amputation at Ankle Joint by Syme's Method; no Support given to the Posterior Flap; Great Displacement backward.*—I. M., 46th Georgia Vols., was wounded March 25, 1865, by a rifle-ball which passed through the ankle joint. Amputation by Syme's method was performed twenty-four hours after the injury. When examined forty days after the operation the wound was healed, but two or three sinuses discharging gave indications of the presence of dead bone. The stump was placed on a pillow, with the extremity projecting over it, without the slightest support to the flaps. The large posterior flap hung pendulous from the end of the stump, its own weight being sufficient to displace it completely from the face of the tibia. No effort had been made to adjust and retain it with adhesive strips."

This case had been pronounced a failure by those who had it in charge, and reamputation was recommended with great unanimity. But no one who has witnessed the benefits of the proper application of adhesive strips in moulding a stump can doubt that the displacement was entirely due to the lack of proper dressings. In Cases IV. and V., the flaps were of the most unpromising character, being large, thick, and infiltrated, but they were moulded to the stump with great ease, and formed a conical extremity of great perfection. In no form of amputation do we regard the kind of dressings and their method of application of so great importance as in amputation at the ankle joint. From the very first there should be proper support given to the posterior flap, and the best form of support is by means of narrow adhesive strips. In the later stages of the treatment, this dressing is of great value in giving proper shape to the stump. When early and thoroughly applied, the strips fix the posterior flap upon the extremity of the limb, and retain it there so firmly that the flexor tendons form attachments to its anterior part, and effectually counteract the contractions of the muscles of the calf. In a well-formed Syme's stump the patient has power to move the heel flap anteriorly as well as posteriorly, showing that the flexors of the foot have become attached to it.

Value of dressing.

In regard to the displacement of the flap in Pirogoff's stump, it is still more evident that the fault is in the after treatment. That serious results follow its displacement is proved by those cases in which reamputation was the only remedy by which the defect was overcome. But it is evident that in these cases little effort could have been made to counteract the contraction of the muscles of the calf, during the period of ossific union of the extremity of the os calcis and the tibia, for when that union was once complete, all farther tendency to dis-

Displacement of flap in Pirogoff's stumps.

placement ceases. This fact is proved by Hewson's cases, IX., X., in which this contraction was immediately counteracted by proper dressings, and the bones united symmetrically, giving a very useful stump.

We must attribute, therefore, the failure to secure a good apposition of the heel flap in either Syme's or Pirogoff's amputation at the ankle to the neglect of proper after treatment. Failure due to after treatment.

V. NOT ADAPTED TO TRANSPORTATION. — It is very generally alleged against ankle-joint amputations, that owing to the large size of the posterior flap and its imperfect nourishment, the stump will not endure transportation. Not adapted to transportation. We have not a sufficient amount of accurate and reliable information on this subject to determine how far this objection is worthy of serious consideration. The accompanying collection of cases contains several instances of patients who had undergone ankle-joint amputations, and were subsequently subjected to transportation long distances without inconvenience. Case IX. proves that Pirogoff's stump, the most liable to be seriously affected by transportation of the two, may not only be transported, but even subjected to much rough handling, without interrupting the process of ossific union. This must undoubtedly be considered an exceptional, perhaps an extraordinary case, but still it must be accepted as proving that the character of the operation does not preclude transportation, even under the most unfavorable circumstances.

Without sufficient facts to decide this question as to the power of ankle-joint stumps to endure transportation, we would suggest that much must depend upon the manner in which dressings are applied. Necessity of proper dressings. If they are carefully adapted so as to thoroughly support the parts, we doubt if the inconvenience will be greater than in an ordinary flap stump.

We may in this place notice a so-called modification of Syme's amputation, performed by Surgeon David Prince, United States Vols., who reports the following case: —

Corporal W. P. Everett, Co. H., 9th Alabama Vols., received a musket-shot on the inner side of the tarsus, in the battle of Williamsburg, May 5, 1862. Prince's modification. There was no counter opening, and it seemed probable that the ball had lodged among the tarsal bones. No ball, however, was found, from which it follows that it must have come out at the same opening at which it went in, or that the injury had been occasioned by some other substance.

The operation was commenced by making an exploratory incision in

the course of the tendon of the tibialis anticus, discovering numerous fragments which were successively removed, when it was found that all the bones of the tarsus were fractured; and on this account it was resolved to amputate the metatarsus, and exsect the tarsus.

A transverse incision was made over the scaphoid and cuboid bones. The separation of the bones was prosecuted by Liston's large cutting forceps, and the soft parts on the plantar surfaces cut in the manner of a flap. The exsection of the tarsus was prosecuted with Fergusson's large gouging forceps, removing the whole of the astragalus and nearly the whole of the calcaneum. As the fragments of bone were pulled away from their attachments, a considerable amount of periosteum and some shells of bone were left for the formation of new bone. The malleoli were cut off by the bites of the forceps, so as to present a tolerably smooth surface to receive subsequently the plantar integument. No other opening was made in the integument than that in front. The parts were kept somewhat in position by a roller bandage, without sutures or any close approximation. The wound must heal and contract by granulation.

The theory of this operation is to preserve the circulation in the plantar integument, without cutting off its supply by dividing the tissues, as is necessary in the manner of cutting the lateral ligaments of the ankle joints. These ligaments are left in connection with the surrounding parts, unless accidentally pulled away by the traction upon the bones to which they are attached. The bones should not be cut away from their attachments, but pulled away, in order to leave as much as possible of the periosteum.

The patient went from under my observation, and I have not since heard from him.

AN APPRECIATION OF THE COMPARATIVE VALUE OF THE METHODS OF AMPUTATION AT THE ANKLE JOINT BY SYME AND PIROGOFF.

Comparative value of Syme's and Pirogoff's methods.

Although an important feature of Syme's original operation was the formation of the principal flap from the heel, we shall, in this comparison, include as Syme's amputations all cases in which the os calcis was completely removed with the other tarsal bones. Pirogoff's method is distinguished by an excision of the posterior portion of the os calcis, and the union of the retained fragment with the tibia. A comparison of these two methods involve for the most part a consideration of the same points as in the comparison of leg and ankle-joint amputations.

Comparative mortality.

1. *Comparative Mortality.* — It is difficult to determine with any degree of certainty the mortality from these operations. That patients died after amputations at the ankle joint is

evident; but it does not appear to what extent this mortality is attributable to the operation. Taking these collected cases as the only basis of comparison, we have the following comparative results: In thirty-seven cases of Syme's amputation, there were four deaths, or a mortality of 10.8 per cent. In ten cases of Pirogoff's amputation, there was one death, or 10 per cent. This difference in mortality is so slight that it is safe to conclude that there is no appreciable difference in the mortality of the two methods.

2. *Comparative Frequency of Reamputation.* — Of thirty-seven cases of Syme's amputation, six were subjected to reamputation, or 16.6 per cent. Of ten cases of Pirogoff's amputation, one case submitted to reamputation, or 10 per cent. of the cases operated upon. In this comparison Pirogoff's amputation would seem to be the more successful. In examining the causes of reamputation it appears that the most frequent cause in Syme's amputation is sloughing of the flaps; retraction of the flaps is given in one case, and necrosis of the tibia in one case. In the single case of reamputation of a Pirogoff's stump, necrosis of the os calcis and tibia had occurred.

Comparative frequency of reamputation.

We cannot consider these figures as conclusive. We need a detailed history of the individual cases, the circumstances attending the first operations and the subsequent history, before the question can be satisfactorily settled. Too frequently, as we have elsewhere stated, the flap sloughs, and the bone undergoes necrosis, or caries, as the result of an unscientific and unskillful operation, or insufficient after-treatment. Still we give them a certain weight of evidence, and as such consider them an approximation to the truth. In any case they prove that there is but little difference in these amputations as regards primary results, and, therefore, that it is in the final serviceableness of the stumps we are to find points of contrast, if any exist.

3. *As regards the Operative Procedure.* — Pirogoff claims for his operation the following advantages: (1.) The tendo Achillis is not divided, and we avoid all the disadvantages connected with its injury. (2.) It also follows that the base of the posterior flap is not thinner than its apex, while the skin on the base of the flap remains ununited with the fibrous sheath of the tendo Achillis. (3.) The posterior flap is not cup-like, as in Syme's method, and its form is therefore less favorable to a collection of pus. (4.) The leg is longer.

Advantages of method of operation.

Mr. Croft's remarks.

Mr. Croft also says: "The advantages of this operation over 'Syme's' (the only operation with which it can be compared) are, that it may be performed more rapidly as to time, leaves a more vascular flap, forms a larger stump, and produces a firmer pad for the subject to walk upon. Less time is occupied in the operation, for the somewhat troublesome dissection of the skin of the heel from the os calcis is avoided, and the os calcis sawn through instead. Greater vascularity of the flap is secured, for the plantar arteries are divided in the hollow of the foot." Mr. Rusk, of the same hospital, confirms these statements, and claims "greater facility and rapidity of execution; less disturbance of the natural relations of the parts which are to form the cushion of support; a solid instead of a hollow flap," in Pirogoff's method.

Syme denies the correctness of these assertions. He states that his operation can be performed in less than a minute. The cup-shaped form of flap which is liable to collect pus is remedied by perforating it, and thus allowing the free and direct escape of its contents. That the vitality of the flap is not materially affected by a proper dissection is proved by the promptness with which union of the flap generally takes place. Professor Van Buren, of New York, reports a case occurring in his own practice in which there was union by first intention. These objections to Syme's amputation cannot, therefore, be regarded as well founded.

Mr. Syme's objections.

On the contrary, Mr. Syme charges that Pirogoff's amputation "deprives his of all its advantages, by rendering it complicated instead of extremely simple; by impairing its constitution; by retaining a portion of the osseous tissue justly liable to the suspicion of relapse; and finally by not being applicable to all cases requiring amputation at the ankle."

The objections of Mr. Syme are refuted by the experience of competent surgeons whose opinions we have already quoted. Like the objections of Pirogoff, above given, they are entirely theoretical, and ample experience has decided them unworthy of credibility.

In regard to the operative procedure, we may conclude that these two methods have equal advantages, and one cannot justly claim superiority over the other.

Hancock's statistics of British surgery.

Mr. Hancock publishes the following table, showing the comparative results of Syme's and Pirogoff's operation in British civil practice:[1] —

[1] *Lancet*, August 11, 1866, p. 144.

Of 219 *of Syme.*	*Of* 58 *of Pirogoff.*
Suppuration specially mentioned in 4.	Suppuration specially mentioned in 11.
Sloughing of flap, 16.	Sloughing of the flap, 1.
Died, 16 (or $7\frac{5}{16}$ per cent.).	Died, 5 (or $9\frac{9}{16}$ per cent.).
Secondary amputation, 13 (or 6 per cent.).	Secondary amputation, 5 (or $9\frac{9}{16}$ per cent.).
Recovered, 185 (or 84 per cent.).	Recovered, 45 (or rather more than 75 per cent.).
Results not stated, 5.	
Period of recovery in 40 cases varied from 3 to 52 weeks.	Period of recovery in 13 cases varied from 6 to 69 weeks.
29 were cured within 12 weeks.	11 were cured within 12 weeks.
34 were cured within 16 weeks.	1 was cured within 24 weeks.
37 were cured within 24 weeks.	1 was cured within 40 weeks.
The remaining 3 between 33 and 52 weeks.	1 was cured within 61 weeks.
	1 was cured within 69 weeks.

COMPARATIVE SERVICEABLENESS OF THE STUMP.

(*a.*) *As regards Unaided Locomotion.* — In comparing leg and ankle-joint stumps, we stated that the latter had far greater advantages than the former, because the stump resulting from an ankle-joint amputation was longer and took direct support on its face. In comparing now two ankle-joint stumps in unaided locomotion, — by which we mean that no artificial limb is applied, and only such covering is employed as a patient applies, — we have to consider, (1) The value of length of limb; and, (2) The power of endurance of the different stumps.

Comparative serviceableness of stump.

1. *The Value of Length of Limb in Progression.* — Pirogoff states that in his operation "the leg appears an inch and a half (sometimes even more) longer than in the three other operations (Syme, Baudens, Roux), because the remnant of the os calcis left in the flap, as it unites with the inferior extremities of the tibia and fibula, lengthens them by an inch and a half."

Value of length of limb.

Mr. Croft remarks: "The length of the stump is a very important point; it (Pirogoff's stump) is longer than in Syme's operation, by the portion of the os calcis left on the flap, which should be quite one inch and a quarter. In the four instances mentioned, the difference in length between the foot operated upon and the sound foot, was never more than three eighths of an inch."

We cannot doubt that the additional length of stump in Pirogoff's operation gives it some advantage over that of Syme, provided the patient has no artificial aid. It requires less compensative

appliance to make up the deficiency of length between the sound and amputated limb. The almost direct pressure which Pirogoff's stump makes upon the surface over which the patient walks, gives greater steadiness in his gait.

Endurance of stump.

2. *Endurance of the two Stumps.* — It is claimed for Pirogoff's operation, that the stump having the extremity of the os calcis as its base of support, must be capable of greater endurance than the stump in Syme's operation, which is simply a flap resting directly upon the newly cut surface of the tibia. There are no facts, we believe, to sustain this conclusion. The alleged tenderness of Syme's stump, we have already shown, is not based on experience, and hence must be regarded as theoretical. In all the trials that have been made with these stumps in simple unaided locomotion, no marked advantages could be claimed by one over the other. And, again, there is no necessity of cutting off the extremity of the tibia; the articular surface is found to unite firmly to the flap.

Adaptation of an artificial limb.

(*b.*) *Adaptation for an Artificial Limb.* — We have already stated that the real test of the usefulness of a stump is its adaptation to an artificial limb. Judged by this standard, we find a marked contrast between the two stumps under examination. The advantages of greater length yielded to Pirogoff's stump when employed in locomotion without aid, prove to be disadvantages when a proper artificial limb is adjusted.

Syme's stump most favorable.

In constructing a useful artificial foot, it is very important that there be space for an ankle joint which shall have full play. In Pirogoff's stump the base of support is so near the floor that the joint must necessarily be on a much lower plane than that of the sound limb, and have but limited movements. This is a practical difficulty which has not been overcome by any mechanical contrivance. In Syme's stump, on the contrary, the base of support is on the same plane as the original ankle joint; and this space enables the mechanical surgeon to construct a joint which acts with as long a leverage and as free motion as the natural joint. In this respect Syme's stump has a real and permanent advantage over that of Pirogoff.

We cannot better conclude this paper than by the insertion of the following recent letter by Pirogoff to Mr. Hancock, of London, in regard to his experience in this method of amputation. It will be seen that, so far from abandoning it, as reported, he is its strongest advocate: —

"As to my osteoplastic operation, I reckon nearly one hundred cases in Russia alone, for accident or disease. My pupil, Dr. Dzemickeritch, was the first who introduced it into the military practice at Odessa, in the case of a soldier wounded at the Alma; and his patient walked, with the assistance of a stick, in about two months. In the Crimea it was practiced principally during the first six months of the siege; and I have registered sixty cases. In December, 1855, when I inspected the military hospitals at Chersow, Eckerterinoslaw, and Charkoff, I found fifteen patients who had been transferred from the Crimea since the date of their operation. The condition of the whole fifteen was satisfactory, notwithstanding nearly half of them had received other injuries. Thus two had undergone also amputation of the fore-arm. In one my operation had been performed upon both his feet. One had the metatarsal bones of his other foot removed. In one the opposite leg, and in another the opposite thigh, had been amputated. Two already walked upon crutches, and two even with a stick only. Pirogoff's last statement.

"A year after the war, I learned that two of the wounded admitted into the hospital at Sympheropol, having submitted to my operation on both feet, still walked on crutches. I ordered them shoes and steel supports. I only know with certainty of seven deaths; and also of one case wherein the flap sloughed, which necessitated amputation of the leg. Secondary hemorrhage occurred in several.

"These are the results of this operation in my military practice; and, judging from the number of patients so operated upon whom I saw subsequently, the mortality could not have been great. The best proof of this is, that among those who have survived, some had the operation performed on both feet; some had at the same time undergone amputation of the other leg and of the other thigh. To be impartial, I will not speak myself of all the advantages offered by this operation with respect to the functions of the limb; but I will repeat what has been communicated to me by surgeons who have adopted it.

"During the year 1863, I visited nearly twenty hospitals and various universities of Germany; and in five of these I was shown patients operated upon according to my method. The whole walked, even without sticks. But the most remarkable case was in the hospital at Heidelberg, under the care of Professor Chelius. A young woman, aged twenty-five, had club-feet from birth. She had tried all sorts of orthopedic treatment without benefit; and Chelius performed my operation upon both feet. When this patient returned from the city to the hospital, I could not discover what she wanted. She walked without a stick, and wore shoes with lateral steel supports.

"Upon subsequently examining the feet operated upon, I have invariably found the portion of the os calcis grown together with the epiphysis of the tibia. In two cases only have I detected a little move-

ment, which, however, did not prevent the use of the limb. Nevertheless, many French and English surgeons doubt even the possibility of such an operation, and find faults discovered by themselves only. This, doubtless, arises from the fact that this 'osteoplastique' operation did not originate with themselves. Thus, Syme pronounces it as an indication of reckless surgical principles. Syme would speak more courteously if he only knew how I had supported his operation of disarticulation when the late Dr. Arnold, inspector of hospitals at St. Petersburg, would have forbidden its employment.

"Another celebrated English surgeon asserts that I have myself abandoned my operation. Whence he learned this, God only knows. Could he have arrived at this conclusion from one of my letters to a surgeon in London, who applied to me for the results of this operation? 'I have not made up my mind,' I replied; 'time will show whether it is worth anything or no.' Malgaigne repeats what he has read in Fergusson, and, probably never having tried my operation, frightens the reader of his 'Operative Surgery,' about gangrene of the flap, the impossibility of adhesion or coalescence, fistulæ, and the pain experienced by the patient in walking. Exactly what never takes place. The contemporaneous school, however, of Germany has treated me much more impartially. Langenbeck, Linhault, Neudörfen, Chelius, Busch, Beliott, and others, have frequently performed my operation with success. O. Weber has enumerated forty cases, and has defined the rate of mortality at 15 per cent. (He found the same rate of mortality in one hundred and one cases of Syme's operation.) In seven cases the wound healed completely in one month. Dr. Kestnor, of the penal hospital at Strasburg, presents also sixteen cases. Of these, the results of six as to functions of the foot remain at present doubtful; in the other ten only one failed as to walking, and in four fistulæ remained. We might suppose that Malgaigne could not have ignored these results, described by his countrymen in a dissertation in the French language; but he assumes to himself the credit of being the inventor of the subastragaloid amputation, although it is due entirely to his countryman Legnerolles. Hence the reason why, at all hazards, he vaunts the advantages of his operation at the expense of others. On the other hand, Hyrth, from purely anatomical considerations, rejects Malgaigne's operation altogether. As to myself, I will not treat it unjustly, but will say in its favor that it preserves a little increased length to the foot, but that it is much more difficult to perform.

"I do not fear the result of my operation; its importance does not consist in the method of amputating, but in a novel osteoplastic principle. My whole merit consists in irresistibly demonstrating by my proceeding that a portion of one bone remaining, naturally connected with soft parts, readily unites with another, and at the same time serves to lengthen the limb and increase its util

have tried my operation. Stromeyer, without any reasons, doubts its success; and in Chenu's report we cannot make out whether, during the Crimean campaign, the French and English surgeons made any distinction between my operation and that of Syme. Of forty-eight operations, twenty-one proved fatal, or 44 per cent.; but with the English, of twelve, only two died, or 16 per cent. During the Italian campaign, Denne saw Neudörfer perform my operation at Verona three times; all three patients recovered. According to Stromeyer's report, during the Holstein campaign four patients, who submitted to Syme's amputation, died."

AMPUTATION AT ANKLE JOINT,

Name.	Residence.	Occupation.	Regiment.	Date when wounded.	Battle.	Missile.	Injury.	What Primary Operation and Method.	What Subsequent Operation and Method.	Where performed and Surgeon.
M. C. M.	—	Lieutenant	5th Mich. Cavalry	April 1, 1865	Five Forks	Conoidal musket ball	Passing through his left ankle joint	Amputation at the ankle was performed. Pirogoff's method. The articulating surfaces of the tibia and calcaneum removed, and the cut surfaces bro't into apposition	—	Surgeon St. Clair, at City Point Hospital
A. B.	—	Soldier	—	1863	Chattanooga or Missionary Ridge	—	—	Pirogoff's amputation, a few days after injury	Amputation of leg early in month of February	Prof Paul Eve, of Nashville, Tenn. Dr. Richard Taylor, of Memphis, Tenn
O. L.	—	—	2d N. H. Vols.	June 10, 1864	Petersburg, Va.	Shell	Injuring right foot	Amputation at the ankle joint by Pirogoff's method	—	—

PIROGOFF'S METHOD.

Treatment.	Progress of Case.	Necrosis.	Atrophy.	Length of Stump.	General Health.	Shortening of Limb.	Usefulness of Limb.	Result.	Remarks.
Carried to the hospital at City Point, April 16, 1865; the patient was transferred to Armory Square Hospital, Washington, D. C. With the employment of stimulants and nutritious diet, with emollient applications to the limb, there was a gradual improvement	On admission to Armory Square Hospital he was in a feeble condition. An erysipelatous blush extended over the knee on the injured side; an abscess had formed in the lower part of the leg, and no union of the flap had taken place. April 28, 1865, symptoms of pyæmic infection supervened; rapidly recurring chills; an icteroid coloration of the skin and conjunctiva, anorexia, and a frequent feeble pulse suggested the gravest prognosis. On May 6th, the grave symptoms began to disappear, and by the end of the month the patient was fairly convalescent. On June 6th, pronounced well; the os calcis had firmly united to the tibia, and there was a good solid stump	—	—	—	Good	—	A good solid stump.	Good	(Spec. 2296, A. M. M. and Photo. 75 in series.) Circular No. 6, Surgeon General's Office, p. 47.
—	Case seen for the first time by the reporter, James M. Holloway, M. D., of Louisville, Ky., in the latter part of January, 1864. The flaps had united, but a number of sinuses communicated with the coaptated surfaces of the calcis and tibia, at the bottom of which denuded bone could be felt upon the introduction of the probe. In addition to these, other sinuses situated on the lateral aspects of the lower third of leg communicated with the sheaths of the tendons. These latter, as far as he could judge from the statement of the patient, appeared subsequent to those leading to the carious bones. The integuments overlying and adjacent to the diseased bone, and inflamed condition of sheaths of tendons presented a remarkably healthy appearance, so much so that the true condition of the stump did not transpire until a more thorough examination was made, while the patient was under the influence of chloroform. Such was the complete disintegration of the calcis and the end of the tibia that amputation of the leg was necessary . . .	—	—	—	—	—	—	—	Reported by James M. Holloway, M.D. Prof. of Anat., of Louisville, Ky., Amer. Jour. Med. Sci., Jan., 1866, p. 55.
—	The case progressed favorably, and terminated in a very useful stump	—	—	—	—	—	A very useful stump	Good	—

AMPUTATION AT ANKLE JOINT,

Name.	Residence.	Occupation.	Regiment.	Date when wounded.	Battle.	Missile.	Injury.	What Primary Operation and Method.	What Subsequent Operation and Method.	Where performed, and Surgeon.
—	—	—	—	—	—	—	—	Pirogoff's amputation	—	—
R.W. H.	—	—	44th N. Y. Vols.	May 3, 1863	Chancellorsville, Va.	—	—	Pirogoff's amputation	—	—
P. B. C.	—	—	12th N. Y. Vols.	May 10, 1864	Near Spottsylvania C't House	—	—	Pirogoff's amputation, July 20, 71 days after injury	—	—
P. L.	—	—	48th N. Y. Vols.	July 18, 1863	Ft. Wagner, S. C.	Fragment of shell	Comminuting tarso-metatarsus except calcis	Pirogoff's amputation performed	—	U. S. Hospital, Hilton Head, six days after injury, by Surgeon Applegate
H. B.	—	—	5th N. Y. Artillery	—	Malvern Hill	Shell	Compound fracture of tarso-metatarsal bones except astragalus and calcaneum	Pirogoff's amputation	—	—

PIROGOFF'S METHOD.—(*Continued.*)

Treatment.	Progress of Case.	Necrosis.	Atrophy.	Length of Stump.	General Health.	Shortening of Limb.	Usefulness of Limb.	Result.	Remarks.
—	Patient progressed very unfavorably, and subsequently sank and died	—	—	—	—	—	—	Died	Reported by Prof. Jas. M. Holloway, *op. cit.*
—	Upon examination on the 8th of July, 1864, fourteen months afterwards, found the stump healed, but the parts were still swollen and œdematous; unable to walk without two crutches; heel drawn upwards, and cicatrix of flap thrown downwards and forwards, so that during locomotion it came in contact with the floor. No trace of the existence of inflammation of the sheaths of the tendons remained, and the bones seemed to be sound	—	—	—	—	—	Walk'd with crutches	Poor	Reported by Jas. M. Holloway, M. D., *op. cit.*
—	The soldier was able to proceed to his home in Georgia, though the stump had not entirely healed, and considerable tumefaction of the stump and leg still existed. The heel was drawn up and the tender cicatrix constituted a portion of the sole of the stump	—	—	—	—	—	—	Poor	Reported by Jas. M. Holloway, M. D., *op. cit.*
—	Stump much enlarged generally; exfoliation from posterior portion of tibia; prognosis highly favorable; leg tumefied; œdematous, cicatrized; almost entire weight borne upon the end .	—	—	—	—	—	—	Fair	—
Lower portion of tibia exsected, and anterior portion of calcaneum; integuments and posterior portion of calcis brought up; united to tibia . . .	Stump compact, finely formed, but the portion of calcaneum useless and embarrassing; artificial appliance ordered; to begin to use a boot as base of support	—	1 inch below patella, 1 in.; at calf, 4 in., at end of stump, ¾ of in.	—	—	2 in.	—	Good	—

AMPUTATION AT ANKLE JOINT,

Name.	Residence.	Occupation.	Regiment.	Date when wounded.	Battle.	Missile.	Injury.	What Primary Operation and Method.	What Subsequent Operation and Method.	Where performed, and Surgeon.
F. R.	—	—	—	Dec. 9, 1864	—	Musket ball	Passing through the tarsus	Amputation at ankle joint (Syme's), Jan. 20, 1865	—	Dr. Buck, at St. Luke's Hospital, N. Y.
J. B.	—	—	—	July, 1861	1st Bull Run	Ball	Passing thro' the right tarsus, fracturing the tarsal bones	Amputation, ankle, Syme's method	—	Assistant Surgeon Gouley, at Wash. Infirmary.
J. M.	—	—	45th Ga. Vols.	M'ch 25, 1865	—	Rifle-ball	Passing thro' the ankle joint	Amputation at ankle joint, Syme's method, 24 hours after injury	—	—
C. O'R.	—	—	164th N. Y. Vols.	May 18, 1863	Spottsylvania, Ct. House	Shell	Striking the right foot	Amputation performed 9 hours after injury, by Syme's method	Feb. 12, 1865, Dr. Mott reamputated 3 inch's above ankle joint, by the circular method	Dr. Briggs, Confed. Surgeon
E. R. C.	—	Soldier	—	—	—	—	—	Amputation of ankle joint, Syme's method	—	—
J. H. R.	Gray, Maine	—	8th Minn. Vols.	Dec. 7, 1864	Murfreesboro, Tenn.	Minie-ball	Passing thro' the tarsus from the dorsum to the heel, making a clean track, and causing a compound fracture of tarsal bones	Amputation at ankle joint, by Syme's method	—	U. S. Gen'l Hospital, at Murfreesboro, Surg. Turner
P. C.		Corp'l	70th N. Y. Vols.	Aug. 29, 1862	Bristow's Station, Va.	Minie-ball	Entering the posterior part of left heel, and was remov'd from beneath the integument of the dorsal face of the tarsus; it completely traversed the tarsal bones	Amputation at ankle joint, Syme's method, two years after gun-shot wound	—	Bellevue Hospital, N. Y., by Dr. Stephen Smith
A. J.	New Eng.	Lawy'r	5th N. Y. Vols.	June 27	Gaines's Mills	Ball	Passing through the tarsal bones	Aug. 1st, Syme's operation performed	—	Dr. Bartholow

SYME'S METHOD.

Treatment.	Progress of Case.	Necrosis.	Atrophy.	Length of Stump.	General Health.	Shortening of Limb.	Usefulness of Limb.	Result.	Remarks.
—	The case did well with a shortening of limb	—	—	—	Good	2½ in.	Firm and useful	Good	—
—	Stump healed kindly, leaving a serviceable extremity; artificial limb applied at the end of one year and two months	—	—	—	—	—	An efficient and useful stump	Good	—
Patient taken to Jackson Hospital, Richmond, Va. The limb was placed upon a pillow without the slightest support to the flaps, by means of dressing. The large posterior flap dragged down by its own weight, formed a large, pendulous, suppurating mass . . .	The case progressed unfavorably, with exfoliation of bone and suppuration. When examined forty days after the amputation, there was still considerable discharge from several points . . .	—			—		—	D'btful	—
—	The flap sloughed. Patient taken to Richmond on the third day	—	—	—	—	—	—	—	—
—	Has been healed, but now open in consequence of an injury.								
—	—			—	—	—	Walks well	Good	—
Patient removed to the U. S. General Hospital, Murfreesboro', and ten days after injury amputation was performed	The posterior flap was short and became subsequently enlarged, but by care, union became firm, and the stump sound and reliable. He walks about with a boot leg, having a thick sole, without inconvenience . . .		—	—	Good	—	Walks well	Good	—
The ankle joint being anchylosed, the tibia was sawn through above the malleoli, and the foot removed; so thick and firm were the flaps that it was quite impossible to place them in immediate apposition. By care in the adjustment of strips the irregular margins of the flaps were moulded into shape	The progress of the case to ultimate recovery was most satisfactory. The portion of the flap which contained the opening and track of the sinus sloughed, but left a healthy granulating surface; the thickened and infiltrated tissues were rapidly reduced, and the flaps were brought together. The stump assumed a perfectly rounded and symmetrical form, with the cicatrix on the extremity. Dr. Hudson adapted an artificial foot to the stump, which after a little use enabled him to walk with ease and but a slight limp . . .	None	Slight	—	Bad	—	Walks well	Good	—
Was moved at once to Savage Station, afterwards to Richmond. Cold-water dressings were kept applied. He was sent with the other paroled prisoners to	The flaps came together perfectly well. The wound began to heal up rapidly; about two weeks after the operation, the wound being healed, erysipe-	None	—	—	Pretty fair	—	Walks well	Good	—

AMPUTATION AT ANKLE JOINT,

Name.	Residence.	Occupation.	Regiment.	Date when wounded.	Battle.	Missile.	Injury.	What Primary Operation and Method.	What Subsequent Operation and Method.	Where performed and Surgeon.
F. J.	—	Lt. Col.	1st Mich. S. Shooters	May 12, 1864	Spottsylvania Ct. House, Va.	Minie-ball	Compound comminuted wound of left tarsus	Amputation at ankle joint, by Syme's method	—	—
B. L.	—	—	12th Mass. Vols.	Sept. 17, 1863	Antietam, Md.	Solid shot	Carrying away the phalanges and metatarsus, and shattering the tarsus	Amputation at ankle joint, by Syme's method	—	Dr. Howard, on the field immediately after injury
M. K.	—	—	14th U. S. Infantry	Nov. 14, 1864	Snicker's Gap	—		Amputation at ankle joint, Syme's method	—	—
T. D.	59 Cameron St.	—	1st Excels'r Brigade N. Y. Vols.	June 1, 1864	Fair Oaks, Va.	Rifle-ball	Causing a compound fracture of the tarsus and metatarsal bones	Amputation at ankle joint performed by Surg. Lewis, Syme's method	Reamputation	Surgeon Lewis, at Savage's Station
J. C.	Altoona, Pa.	Labor'r	76th Penn. Vols.	July 10, 1863	Ft. Wagner, S. C.	Musket ball	Causing compound comminuted fracture of tarsus	Amputation of ankle joint, by Syme's method, 24 hours after injury	Reamputation thro' the leg, Sept. 27, 1863	At Fort Schuyler, N. Y.
J. C.	U. S. N.	Coxswain	U. S. N.	May 31, 1864	Appomattox River, Va.	—	Compound comminuted fracture of the tarsal bones, with laceration of soft parts of left foot.	Amputation at ankle joint performed 1 hour after the injury, Syme's method	—	Ass't Surg. Gregory, U. S. N.
J. E. M.	—	—	8th N. Y. Cavalry	July 10, 1863	Funkstown, Md.	Rifle-ball	Entered the left foot at the junction of the tarso, metatarsal bones, and emerg'd behind the external malleolus	Amputat'n performed by Syme's method, at ankle joint, 9 h'rs after the injury was received	—	—
W. S.	Kirkland, N. Y.	Student	39th N. Y. Vols.	May 3, 1863	Chancellorsville, Va.	Unexploded shell	Comminuting the phalanges, metatarsal bones and a portion of tarsus of right foot	Amputation of the ankle joint was performed by Syme's method	—	On the field by Surgeon Wood, 24 hours after injury

SYME'S METHOD.—(*Continued.*)

Treatment.	Progress of Case.	Necrosis.	Atrophy.	Length of Stump.	General Health.	Shortening of Limb.	Usefulness of Limb.	Result.	Remarks.
Baltimore; admitted into the National Hospital, July 21. The skin was laid open freely, the integument sloughed. Under the use of quinine, whiskey, and iron, the man's general condition improved . . .	las attacked the fibula side of the stump, and extended up the leg, chiefly on that side. Matter form'd, the skin became undermined, and small perforations occurred. The healing of the stump progress'd in spite of the complication. Sept. 4th, both the stump and the wound left after the incision are nearly healed up								
—	The patient made a slow recovery, with considerable retraction of flaps; the cicatrix continued tender for a considerable period; at the end of seven months an artificial limb was appli'd, which served a good purpose	—	—	—	—	8½ in.	Useful	Good	—
—	Patient made a good recovery. The stump lacks symmetry, but it is sound and highly serviceable		1 inch below patella, ½ inch; at calf, 3½ inches; at end of stump, 1½ inch		Good	3 in.	Useful	Good	—
—	No history of case given. From a photograph of the stump it appears that the amputation was successful in the final results	—	—	—	—	—	—	Good	—
Patient removed to the steamer Vanderbilt	Sloughing of the flaps occurred, and on June 7th, reamputation performed; patient recovered. Artificial limb applied	—	Proximal portion ½ inch; distal portion 3½ inch.	6 in.	—	—	Walks with aid of artificial limb	—	—
—	Necrosis of tibia occurred. Stump nearly well	Necrosis of tibia	Atrophied	—	—	—	Serviceable	—	—
—	Ten months after the amputation, there was some tenderness of the stump and considerable atrophy of the limb. An artificial limb was appli'd which gave him a useful stump	—	Considerable	—	The patient made a good recovery	2 in.	Useful	Good	—
—	The case progressed unfavorably for a time, but finally the wound cicatrized, leaving considerable hypertrophy of tissues and some tenderness. Eventually an artificial limb was applied, the stump became very compact and firm, and the patient was able to walk with comfort . . .	—	—	—	Good	—	Able to walk with comfort	Good	—
—	Wound healed rapidly, and the flaps made an excellent covering. The cicatrization was complete; he was able to walk freely with only a felt covering to the stump	—	—	—	Good	—	Able to walk freely	Good	—

AMPUTATION AT ANKLE JOINT,

Name.	Residence.	Occupation.	Regiment.	Date when wounded.	Battle.	Missile.	Injury.	What Primary Operation and Method.	What Subsequent Operation and Method.	Where performed, and Surgeon.
I. S. M.	Tonawanda, N. Y.	Farmer	100th N. Y. Vols.	July 18, 1863	Ft. Wagner, S. C.	Musket ball	Causing a compound fracture of tarsus	Amputation by Syme's method at ankle joint	—	Dr. Cutler, 4 months after injury
P. F.	—	—	1st C. S. Battery	June 3, 1864	Cold Harbor, Va.	Minie-ball	Passing through the right ankle joint	Amputation at ankle joint, by Syme's method, 28 hours after injury	Reamputation performed	Dr. Richardson, at Seabrook Hospital Richm'nd, Va.
A. L. S.	—	Boot and shoe maker	20th Mass. Vols.	May 3, 1863	Fred'icksburg, Va.	Spiral case shot	Passing through the ankle joint, destroying the articulation	Amputation performed on the field, owing to destruction of heel, the flaps were formed fr. lateral parts of ankle. Lateral flaps	—	On the field 4 h'rs after injury
C. D.	—	—	—	June 24, 1864	—	Fragment shell	Striking sole of foot just anter'r to heel, lacerating soft p'rts extensively, and injuring the tarsal and metatarsal bones	Amputation at ankle joint was performed on the 3d day. Method lateral flaps	Surg. N. P. Moon, Mower, U. S. A. Hospital removed frag'nts	Mower, U. S. A. Hospital. Surg. N. P. Moon
D. G.	—	—	8th Ill. Cavalry	June 29, 1862	White Oak Swamp	Ball	Entering below the malleolus externus of the right foot, and emerging through the second and third cuneiform bones	Amputation at ankle joint, by Syme's method	—	
G. C.	Penn.	—	1st Penn. Vols.	June 30, 1862	Before Richm'nd	Ball	Taking its direction through the instep of right foot	Amputation at ankle joint, by Syme's method	—	On hospit'l transport
H. H. C.	Genesee, N. Y.	—	100th N. Y. Vols.	May, 1864	Drury's Bluff	Fragment of shell	Left foot extensively lacerated	Amputation at ankle joint, performed with lateral flaps	—	Surgeon Kettlinger

SYME'S METHOD.—(*Continued.*)

Treatment.	Progress of Case.	Necrosis.	Atrophy.	Length of Stump.	General Health.	Shortening of Limb.	Usefulness of Limb.	Result.	Remarks.
—	The stump healed kindly, but the anterior flap being rather long, and the posterior short, the cicatrix is rather too much on the face of the stump. At the end of nine months an artificial limb was applied, and the stump prov'd very serviceable	—	—	5¾ in.	—	—	Stump very serviceable	Good	—
—	The flaps are stated to have retracted so as to necessitate reamputation. Recovered .	—	—	—	Good when wounded	—	—	—	—
—	Abscesses form'd, but the flaps united, and with the exception of the cicatrices left by the abscesses the stump was sound and very serviceable. At the end of three months he could bear his weight upon it, experiencing a prickling sensation; at the end of five months an artificial limb applied, and the patient could walk with ease and comfort	—	An in. below the knee, ¾ of an inch; at calf, 3½ inches; at the end of stump, ¾ of an inch	—	—	2½ in.	Walks well with artificial limb	Good	—
Owing to the destruction of the soft tissues about the heel, the flaps were made from the sides of the ankle and foot, and partially from the sole on the external part. Water dressings were applied . . .	For a few days the case progressed favorably; sloughing then occurred to a small extent. During the following month three abscesses formed in the lower part of the leg, one being quite large. After the removal of the fragments, the case progressed favorably, wound cicatrized, leaving a well-formed but somewhat tender st'mp	A slight necrosis of the lower end of tibia occurred	—	—	—	—	—	Good	—
—	Patient healthy, sanguine temperament; not in the habit of drinking liquors in excess. The wound (Sept. 1) healing up and doing well, except the part corresponding with the fibula; took a number of detached pieces of bone out .	—	—	—	Aug. 14, general health good	—	—	—	After the necrotic part of the fibula is resected, the wound will undoubtedly heal fast.
Taken prisoner and sent to Richmond; kept there two weeks; exchanged July 22. August 1, flaps shrink somewhat; brought ends together by straps	Aug. 7th, doing well, healing. Aug. 21st, abscess formed on the internal side of foot; opened. Sept. 3d, doing well, and soon in a condition to be dismissed	—	—	—	—	—	—	—	—
—	Case did well, and the stump was sound and serviceable though the flaps were composed of tissues from the lateral parts of the ankle; the same patient suffer'd a Chopart's amputation of the right foot, which did well.	—	—	—	—	2½ in.	Useful limb	Good	—

INVESTIGATIONS

UPON

THE NATURE, CAUSES, AND TREATMENT OF HOSPITAL GANGRENE, AS IT PREVAILED IN THE CONFEDERATE ARMIES, 1861–1865.

BY

JOSEPH JONES, M. D.

PROFESSOR OF CHEMISTRY IN THE MEDICAL DEPARTMENT OF THE UNIVERSITY OF LOUISIANA, NEW ORLEANS, FORMERLY SURGEON IN THE PROVISIONAL ARMY OF THE CONFEDERATE STATES.

INTRODUCTION.

History of Investigations on Hospital Gangrene. — Gunshot Wounds treated in Augusta, Georgia, during the Spring and Summer of 1862. — Moist Gangrene of Rare Occurrence during the Earlier Periods of the War for Confederate Independence. — The First Case which came under the Observation of the Author at all resembling Hospital Gangrene, occurred in the Month of July, 1862. — History of this Case — Investigations upon this Disease, instituted during the Months of August, September, and October, 1863, in the Confederate General Hospitals at Summerville, Charleston, and Columbia, South Carolina, and in Richmond, Gordonsville, Charlottesville, and Lynchburg, Virginia. — Effects of Incessant Labors, Excitement, Fatigue, Bad Water, and Foul Air upon the Confederate Soldiers defending the Earthworks on Morris Island, and the Ruins of Fort Sumter in Charleston Harbor. — Observations upon the Moist Gangrene which prevailed amongst the Confederate Wounded who crowded the General Hospitals in Augusta, Georgia, after the Battle of Chickamauga. — Inquiries instituted in the Field and in the Hospitals, and amongst the Medical Officers of the Army of Tennessee during the Months of June and July, 1864. — Outline of Labors submitted to Surgeon-General. — Clinical Investigations and Post-mortem Examinations instituted amongst the Federal Prisoners at Camp Sumter, Andersonville, Georgia, and in the General Hospitals at Macon and Vineville, September, October, and November, 1864. — Objects and Results of these Labors upon Hospital Gangrene and Small-pox. — Form of Circular containing Inquiries on Hospital Gangrene, addressed to Confederate Surgeons. — Method of presenting the Results of these Investigations. — Definition of Certain Terms. — Form of Confederate Reports of Sick and Wounded. — New Form of Sick Report. — Remarks upon the Classification of Diseases. — Division of Gangrene into Gangræna Sicca, Humida, and Phagedæna Gangrænosa. — Use of the Terms Mortification, Gangrene, and Sphacelus, by Various Authors, as Galen, Fabricius, Hildanus, Samuel Sharpe, Percival Pott, John Hunter, John Pearson, Samuel Cooper, John Syng Dorsey, John Abernethy, Charles Bell, Sir Astley Cooper, John Thomson, Baron Boyer, Baron Larrey, Mr. Guthrie, Cholius, R. Carswell, and Copland. — Observations upon the Method of Investigation and Classification of the Phenomena of Mortification: 1. Mortification arising from Mechanical Injuries, and the Local Action of Physical and Chemical Agents; 2. Mortification arising from and following Inflammations of Important Organs and Structures, without any External Injury; 3. Mortification arising from Constitutional Derangements, and Alterations in the Circulatory Apparatus, without any Local Injury or Internal Inflammation; 4. Mortification arising from the Action of Special Poisons, either developed within the System or introduced from without, through the Alimentary Canal, Respiratory System, or Skin, or through the Blood, or through Wounds and Ulcers. — Notes upon the History of Hospital Gangrene. — Records of the Ancients furnish only Negative Testimony. — State of Medical Science amongst the Assyrians and Padæans. — Armies of the Ancients subject to very much the same Diseases as the Modern Armies; Examples: Pestilence in Grecian Army; in the Army of Xerxes; amongst the Hebrews. — Scurvy known to the Ancients. — Very few Wounded survived the Ancient Battles. — Homer's Description of the Battles between the Grecians and Trojans. — Time at which regular Army Surgeons were first employed. — Hebrews; Moses; Homer's Account of the Wounding of Menelaus; Darius; Alexander; Roman Armies. — History of the Establishment of Hospitals. — Authors who have treated of Hospital Gangrene, Pliny, Paré, Lamotte, Poiteau, Leonard Gillespie, and others.

THE following Report on Hospital Gangrene was drawn up for the use of the Medical Department of the Confederate States of

[illegible] In the investigations and discussions, the author endeavored to pursue the inductive method. While striving to [illegible] among the Confederate soldiers [illegible] he has been under the earnest desire to present [illegible] as possible, during [illegible] struggle with a mighty [illegible] without large libraries, and cut off [illegible]

[illegible] which might appear of small importance to [illegible] would rather be a distinguished [illegible] than remove the most [illegible] from the mind of a disease, is with me a more [illegible] that I aim at setting off my own [illegible] mind with matters of mere spec- [illegible] with subjects which can come before him [illegible] On the other hand it may be said that a disease [illegible] in army and navy hospitals is [illegible] during a season of war, and can have but little [illegible] Apart from the large amount [illegible] present in this report, and the interest which [illegible] from the time and circumstances of its production, [illegible] that at hospital gangrene was almost [illegible] during the [illegible] the time of the [illegible] I feel assured that we may reasonably believe that [illegible] people will cease with [illegible] we are not [illegible] at the experience now recorded will prove of value in the conduct of future wars.

During the spring and summer of 1862, I examined and treated in the general hospital in Augusta, Georgia, many cases of gunshot wounds from Virginia and the coast of South Carolina. As this was the only hospital at this post, and as it was located upon the direct line of railroad travel from Virginia, the number of transferred and furloughed wounded soldiers who applied for medical aid was by no means inconsiderable; and from the previous fatiguing travel to which the wounded had been subjected, this was a favorable point for the examination of the origin of hospital gangrene. Although in many cases the wounds had not been dressed for several days, from the time that the soldiers had left the battle-field or hospital in Virginia until they reached Augusta, in no case did I observe

Hospital gangrene during the early periods of the war

any appearance of moist gangrene. In some cases the wounds contained living maggots, generated during the passage from Richmond in the cars, and in others erysipelas had made its appearance, and the parts were swollen and red; but still, in these earlier periods of the war, as far as my observation extended, the gunshot wounds discharged well-formed pus, and were free from moist gangrene. This observation was also true of a number of gunshot wounds from the battle of Secessionville (June 16, 1862), which came under my treatment.

The first case at all resembling hospital gangrene which came under my notice, occurred in the month of July, 1862. A young soldier belonging to one of the regiments of Florida volunteers, was stabbed in a rencounter in a drinking saloon. The slender dirk entered the anterior and superior portion of the scrotum, on the right side, near where it united with the integuments of the abdomen, and following very nearly the track of the spermatic cord for about half an inch, passed towards the left side, grazing the root of the penis. One or more blood-vessels appear to have been severed, although at the subsequent examination, when the parts were swollen and infiltrated with blood, it was impossible, without enlarging the wound, to discover the ends of the vessels. This unfortunate young soldier was brought to the Confederate hospital eight hours after the reception of the wound. The scrotum was distended with blood, and resembled in color, and in its distended purplish and blackish skin, a Guinea squash or egg-plant. After carefully probing the wound with the finger, and after careful examination, although the severed ends of the vessels were not secured, still it was ascertained that the hemorrhage had ceased. The lips of the wound were drawn together, the enlarged scrotum was suspended and elevated by a bandage, and cloths saturated with ice-water applied. Upon the third day, finding that the scrotum had not diminished, but had rather increased in size, several free incisions were made into the most dependent portions. Blood was effused and coagulated throughout the cellular tissue. Nothing but bloody serum issued from the incisions. The size of the tumor was diminished somewhat by this loss of fluid. The weather was very warm, and in the course of a few days it was evident that the effused blood in the scrotum was undergoing decomposition; bright lines of inflamed lymphatics shot up from the scrotum on both sides towards the abdomen, and the skin of the groin and lower portions of the abdomen presented an

The first case resembling hospital gangrene which came under the observation of the author, originated in the hospital.

inflamed reddish, purplish, and greenish discolored appearance. The marks of inflammation and disorganization progressed most rapidly on the uninjured (left) side, no doubt because the veins and lymphatics were not severed on this side; and the left thigh, groin, and lower portion of the abdomen on this side soon presented a swollen green, purplish, grayish, and in parts blackish look, as if the parts were undergoing rapid decomposition. The odor from the scrotum became insupportable; chlorine, nitric acid, and tar fumigations only partially mitigated the stench. The abscess, or rather gangrenous mass upon the left groin and lower portion of the abdomen, progressively increased, and the inflamed lymphatics and black distended veins could be seen radiating from it in all directions. When I plunged my lancet into this elevated purplish and greenish putrid-looking mass, it encountered no resistance; the integuments and tissues appeared to be completely dissolved, and a dark greenish and purplish, horribly offensive matter, mixed with numerous bubbles of air, poured out in large quantity. The entire mass of coagulated blood and infiltrated tissues now sloughed off, and left the white and apparently healthy testicles entirely exposed. The skin of a large portion of the penis also sloughed off. During these changes, the whole complexion assumed a sallow, unhealthy, leaden hue. Death closed this distressing case in less than seven days after the reception of the wound. This case presented several points of interest.

1. It was evident that death was not caused by the severity of the wound, for no vital organ was injured, and the hemorrhage was inconsiderable. Death was evidently due to the absorption and poisonous effects of the products of the decomposed gangrenous blood and tissues.

Death in the case of wound of scrotum, caused by the absorption and poisonous effects of the products of the decomposed gangrenous blood and tissues.

2. The cerebro-spinal nervous system presented but few evidences of disturbance. The patient retained his senses to within a few moments of death, and was at no period restless. The low, muttering delirium, as well as the twitchings of the muscles and tendons characteristic of adynamic fevers, were at no time present. No active pain was suffered, and the patient appeared to be insensible to his distressing condition; he expressed no fears of death, did not complain of the horrid stench, and although fully warned of his true situation, and informed that every hope of life had vanished, he actually traded for a watch two or three hours before his death.

3. The pulse, previous to the gangrene of the scrotum and the formation of the gangrenous abscess, was full and soft; after

evidences of the disorganization of the tissues and blood, it became rapid and feeble. The heat of the body was somewhat elevated, but not to the degree common in idiopathic fevers. The skin felt relaxed and moist, and the sweat gave a sticky, clammy, unpleasant feeling to the hand. Throughout the tongue was clean, moist, and relaxed.

4. The complexion assumed a leaden hue, and the marks of death were discoverable in the pinched nose, sunken eyes, hollow temples, the rough, dry, tense skin of the forehead, and the dull leaden eye, for thirty-six hours before death.

5. No case of gunshot wound had ever been treated in the small room in which this patient lay. Several cases of typhoid fever, and quite a number of other diseases, as malarial fever and measles, had been treated in this and the adjoining room, from the foundation of the hospital; but for a week or ten days before the entrance of this patient there had been no serious cases of disease, and the two rooms had been cleansed.

6. The poisonous matters causing the gangrenous abscess were evidently generated within the injured structures of the patient, and were not derived from any extraneous source. The passage of the scrotum into the gangrenous state was due, not to the introduction of a special poison from without, but to the preëxistent state of the constitution, and the decomposition of effused blood in this hot climate, in a dependent organ, and in tissues of low vitality.

During the months of August, September, and October, 1863, I visited the sick and wounded in the general hospitals in Summerville, Charleston, and Columbia, South Carolina, and in Richmond, Gordonsville, Charlottesville, and Lynchburg, Virginia, and instituted investigations and inquiries upon hospital gangrene and other diseases.

Effects of foul air in bomb-proofs of Morris Island upon wounded.

The trials and sufferings of the brave defenders of the Confederate earthworks on Morris Island, and of Fort Sumter in Charleston harbor, were of no ordinary character. In the history of warfare, troops were never subjected to a severer ordeal than that endured for days and nights by the gallant defenders of Batteries Wagner and Gregg. Shut up upon the end of a barren sand island, in two small sand forts, with no navy to assist them, the Confederate soldiers were almost encircled by the land batteries and iron-clads of the enemy, armed with the heaviest and most effective ordnance known to modern warfare. During the severe and incessant bombardment in this

intensely hot weather, the Confederate soldiers were compelled to remain in the bomb-proofs.

With more than one thousand soldiers crowded into these subterranean passages, with necessarily imperfect ventilation, the atmosphere became loaded with noxious and offensive exhalations. In addition to all this, it was impossible to convey water and provisions to the forts, except during the night, and the water of the island was hot, brackish, and nauseous. The meat and food kept in the bomb-proofs rapidly spoiled, through the action of the foul emanations from confined living beings. The effects of the hot, foul air, continuous labors, and excitement upon the men, were marked, and hundreds were incapacitated for duty by sheer exhaustion, or by severe bowel affections resulting from these causes, and especially from bad water and food, or by malarial fevers arising from the exhalations of the island, the sandy surface of which was underlaid by an ancient salt marsh. The wounded especially suffered from these causes, and the gunshot wounds assumed in many cases an unhealthy appearance, even before leaving the bomb-proof hospital. The only ameliorating agent was the stimulating ozone of the sea air, which tended to counteract the effects of the other deleterious influences.

Effects of exposure, diet, and water upon the progress of gunshot wounds, shown in the case of the troops serving in and around Charleston, S. C.

I embraced the opportunity of comparing the Confederate and Federal wounded in the general hospitals in Charleston and Columbia, South Carolina. The wounded Federals captured during the assaults upon Battery Wagner, who received similar attention with the Confederate soldiers, recovered more rapidly from their wounds than the Confederate soldiers. The difference in the healing of the wounds appeared to be due to the fact, that the Federal soldiers wounded and captured in these attacks had been brought in a high state of health from the most salubrious localities in the outer range of sea islands, immediately into action, without being subjected to the action of malaria and the excitement and fatigue of incessant bombardment and the foul air of bomb-proofs, which resembled more nearly caverns in the earth.

Large hospitals of Virginia afforded a good field for the investigation of hospital gangrene.

The extensive Confederate hospitals in Richmond, Charlottesville, and Lynchburg, Virginia, presented a wide and important field for the investigation of hospital gangrene. The hospitals were visited, and the most interesting cases subjected to critical observation, the gangrenous matter carefully examined under the microscope, drawings exe-

cuted of the microscopical appearances at different stages of the disease, and the effort made to excite and direct the attention of the surgeons to the careful investigation and record of cases, and to the determination of important questions, as the local or constitutional, and the contagious or non-contagious nature of the disease; and experiments with the gangrenous matter were proposed and instituted upon living animals. During these labors I was enabled to determine that pus is not formed in the truly gangrenous matter, and that its appearance is one of the most important signs of improvement in the wound; and further, that constitutional symptoms almost invariably accompany the progress of the local disease.

Effects of crowdings upon the wounded received in Augusta, Ga., from the battle of Chickamauga.

Upon my return to Augusta, the Confederate hospitals were found crowded with wounded from the bloody battle of Chickamauga. One thousand and fifty sick and wounded soldiers, about nine hundred of whom were recently wounded, were sent from the battle-field of Chickamauga to Augusta. The majority of the wounds were slight, and of the extremities.

Origin and extensive prevalence of hospital gangrene attributable to overcrowding in box cars and imperfectly ventilated hospitals.

The battle of Chickamauga was fought September 18–20, and the wounded were not received in Augusta until the 26th–28th, or from eight to ten days after the reception of the wounds.

Not only were these soldiers much crowded in the cars, and without the proper dressing and attention to their wounds during the tedious journey of near three hundred miles, but many of them lay out in the railroad depot, with little or no accommodation or attention to their wounds, for from forty to eighty hours after arriving in Augusta. The hospital accommodations were wholly inadequate to the proper treatment of this number of wounded, and they were crowded into houses and churches, the hygienic conditions and arrangements of which were defective. Thus the Second Georgia Hospital, with a capacity, according to the regulations, in cubic feet, of only 165, received 273 sick and wounded; the Third Georgia Hospital, first division, with a capacity of 130, received 220; second division of the Third Georgia, with capacity for 162, received 370 sick and wounded soldiers. The capacity of the Presbyterian Church, impressed as a hospital, was only 112; nevertheless 240 wounded men were crowded into it; the pews were not removed, the seats were converted into bunks, and the wounded men laid in the pews.

The capacity of the Catholic Church was only 50, and yet it

received 130 wounded. Hospital gangrene appeared first in the Presbyterian Church, a few days after the crowding of the wounded into the imperfectly ventilated building, surrounded by a dense and damp shade of large oak-trees.

Not a single wounded soldier escaped gangrene in this building. The upper portion of the church was more imperfectly ventilated than the lower, and in addition to this the heated air, loaded with the exhalations from the lungs and putrid wounds, ascended; and the cases of gangrene in the gallery were, as a general rule, severer than those treated below on the first floor. The disease next appeared in the Catholic Church, and here also all the wounded were attacked; and finally the wounded of the Second and Third Georgia Hospitals (proper) were visited, and a number of cases terminated fatally. The most interesting cases were selected, and careful observations made upon the changes of the secretions, excretions, temperature, pulse, and respiration, and upon the pathological alterations after death.

During the months of June and July, 1864, I visited the Army of Tennessee, in Northwestern Georgia, and instituted amongst the medical officers a series of inquiries upon the history of various diseases, and especially upon typhoid fever and hospital gangrene. The prolonged occupation by the Confederate forces of Kenesaw Mountain, and of the heights around Marietta, afforded a favorable opportunity for the examination of the experience of the Medical Director, and of many of the chief surgeons of the corps, divisions, brigades, and regiments. I was able to ascertain, by these inquiries both amongst the field and hospital surgeons, that but few cases of moist gangrene had appeared amongst the Confederate wounded after the battle of Chickamauga.

The number of cases of hospital gangrene appeared to increase in proportion to the distance which the wounded were transported from the battle-field. Thus, in the hospitals of Dalton, Rome, Cassville, Kingston, and Marietta, very few cases were reported, and the number was greater in Atlanta. The origin and remarkable spread of the disease amongst the wounded transferred to Augusta, appeared to be due to the transportation of the wounded for near three hundred miles in close cars, with little or no attention to the wounds; to the crowding of the hospitals far beyond their capacity; and to the sudden change of climate, from the salubrious regions of Northern Georgia, elevated one thousand feet and over above the level of the Atlantic Ocean; to the malarious climate and low basin of Augusta, elevated only about one hundred and fifty feet above tide-water, and surrounded with hills.

In response to the direction of the Surgeon-General, I prepared in the month of August, 1864, a brief report upon hospital gangrene, giving the general results of the labors up to that time; and immediately after this was forwarded, I repaired to Camp Sumter, Andersonville, Georgia, and instituted a series of investigations upon the diseases of the Federal prisoners. The field was of great extent, and of extraordinary interest. There were more than five thousand seriously sick in the hospital and stockade, and the deaths ranged from ninety to one hundred and thirty each day. From the establishment of this prison, on the 24th of February, 1864, to the 1st of October, over ten thousand Federal prisoners died; that is, near one third of the entire number perished in less than seven months. I instituted careful investigations into the condition of the sick and well, and performed numerous post-mortem examinations, and executed drawings of the diseased structures. The medical topography of Andersonville and the surrounding country was examined, and the waters of the streams, springs, and wells around and within the stockade and hospital carefully analyzed. Diarrhœa, dysentery, scurvy, and hospital gangrene were the diseases which have been the main causes of the extraordinary mortality. The origin and causes of the hospital gangrene which prevailed to such a remarkable degree and with such fatal effects amongst the Federal prisoners, engaged my earnest consideration.

Investigations instituted amongst the sick and wounded Federal prisoners confined at Camp Sumter, Andersonville, Ga.

The scorbutic condition induced by salt meat and farinaceous food, without fresh vegetables, modified the course of every disease, poisoned every wound, however slight, and lay at the foundation of those obstinate and exhausting diarrhœas and dysenteries, which swept off thousands of these unfortunate men. Such was the state of the solids and fluids in systems debilitated by long confinement, despair, and poor diet, that slight injuries, abrasions, and scratches of the surface, and even the bites of small insects, were in many cases followed by such rapid and extensive gangrene as to destroy extremities and even life itself.

After the conclusion of the labors amongst the Federal prisoners at Andersonville, a series of inquiries and investigations were instituted upon the hospital gangrene, which prevailed to so great an extent amongst the hospitals connected with the Army of Tennessee during the recent disastrous campaign in Northwestern Georgia, and especially after the evacuation of Atlanta. The doubtful if not dangerous and

Investigations instituted in the general hospitals of the Army of Tennessee.

disastrous policy of collecting the cases of hospital gangrene into one hospital devoted exclusively to its treatment, was inaugurated amongst the general hospitals of the Army of Tennessee located in and around Macon, and three hundred and eighty-five cases of hospital gangrene were treated at the Empire Hospital, in Vineville, near Macon, during the months of August, September, and October.

Sixty-five cases of gangrene terminated fatally during these months at the Empire Hospital; that is, during this short space, one sixth of all the cases proved mortal. The gangrene hospital was located in a depression covered with small scrub oaks, just where the Vineville road meets the railroad, and directly opposite to the Confederate States Laboratory. The effects of location, and change of climate, and the crowding of the gangrene patients into hospitals devoted specially to its treatment, was examined; and numerous examinations and analyses of the blood and excretions were made, and life-like drawings executed of the gangrenous parts, illustrating not only the appearances presented by the wounds at the different stages of the disease, but also the permanent disability which gangrene produces by the contraction of the injured muscles. The origin and causes of this disease in the Army of Tennessee were investigated, the hospital records examined and consolidated, and numerous inquiries relating to hospital gangrene addressed to the various medical officers.

One of the wards of the Empire Hospital was devoted to the treatment of small-pox, and several cases occurred in which variola appeared in patients who had but recently suffered with hospital gangrene, and whose wounds were still extensive and in an unhealthy condition.

The two diseases, small-pox and hospital gangrene, were investigated side by side in the same manner, and the results of the analyses of the excretions and of the post-mortem examinations compared, in order that the difference between the actions of two poisons of animal origin might be determined. This comparison was peculiarly interesting, because in the one case the action of the animal poison produced specific effects which altered the entire constitution, and could not be repeated, whilst in the other the animal poison produced no specific alteration of the system, and so far from affording any immunity, rather tended to render the system affected more liable to its action.

The following form of the inquiries which I drew up and addressed both in person and by circular to a large number of the

medical officers of the Confederate army, is now presented, as it gives an outline of the general method pursued by me in the investigations upon hospital gangrene recorded in this volume.

INQUIRIES UPON HOSPITAL GANGRENE.

AUGUSTA, GA., *August* —, 1864.

SURGEON —— ——,
—— ARMY OF TENNESSEE.

SIR, — I respectfully call your attention to the following order of the Surgeon-General: —

CONFEDERATE STATES OF AMERICA,
SURGEON-GENERAL'S OFFICE, WAR DEPARTMENT,
RICHMOND, VA., *August 6th*, 1864.

Inquiries upon hospital gangrene, addressed by author to Confederate surgeons.

Surgeon Joseph Jones is directed to institute an extended investigation upon the causes, pathology, and treatment of fevers, and the relations of climate and soil to disease.

Surgeon Joseph Jones will visit those parts of the Confederate States, and prosecute his investigations in those cities, armies, and regimental and general hospitals, which he may deem necessary, as affording suitable fields for the establishment of the results indicated in this order.

Medical directors of the field and hospital, and chief surgeons of corps, divisions, districts, and brigades, and surgeons and assistant-surgeons of regiments and general hospitals, will afford every facility to Surgeon Jones to carry out these instructions, and will respond as far as possible to his inquiries by letter and circular, and will furnish him with copies of all field and hospital reports which he may deem necessary for the illustration of the various subjects of inquiry indicated in this order.

Surgeon Jones will embody the results of his labors relating to the diseases of the Confederate army in substantial volumes, and will deposit them in the Surgeon-General's office, for the use of the medical department of the Confederate army.

(Signed) S. P. MOORE,
Surgeon-General C. S. Army.

In the prosecution of these inquiries, the inductive method has been followed, and individual facts have been observed and recorded, and general principles established by the analysis, comparison, classification, and combination of the facts and phenomena. In an inquiry into the causes, pathology, and treatment of different diseases, the first and most essential labor consists in the accurate delineation of the symptoms and phenomena (natural history) of diseases, and the effects of remedies, based upon the critical observation and record of the symptoms during life, and the pathological alterations after death.

The entire period of a long and active life would be insufficient for the full execution in this manner of the labors indicated; and in truth such extended investigations could be thoroughly conducted only by a large corps of zealous and intelligent observers, laboring in concert systematically, and supplied with the materials and instruments of

modern chemical, physiological, and pathological science. "The difficulties of medical observation and inquiry can be adequately conceived," as Sir Henry Holland most truly remarks, "by the medical man alone. Neither those accustomed to legal evidence only, nor such as have pursued physical science in its more simple material forms, can rightly apprehend the vast difference made by the introduction of the principle of life; or yet more, of the states and phenomena of mind, in connection with bodily organization. We have here a new world of relations, occult and complex in their nature, to be reasoned upon and resolved, with a principle of change, moreover, ever operating among them, and deviations from nature, under the forms of disease, which render all conclusions liable, in a thousand ways, to error."

No lengthy argument is necessary to prove that experiments and instrumental aids are necessary characteristics of the inductive method, and that observation by the unaided senses, and induction by the unaided intellect, would fail to advance the cause of medicine much beyond the state in which it was left by the ancient Greek school of medicine. Bacon has well said that "the unassisted hand, and the understanding left to itself, possess but little power. Effects are produced by the means of instruments and helps, which the understanding requires no less than the hand. And as instruments either promote or regulate the motion of the hand, so those that are applied to the mind prompt or protect the understanding." In like manner the cautions of Lord Bacon against too hasty generalizations, even when experiment is used, are well worthy of the consideration of the medical investigator.

"Even when men build any science and theory upon experiment, yet they almost always turn with premature and hasty zeal to practice, not merely on account of the advantage and benefit to be derived from it, but in order to seize upon some security in a new undertaking of their not employing the remainder of their labor unprofitably; and by making themselves conspicuous, to acquire a greater name for the present. Hence, like Atalanta, they leave the course to pick up the golden apple, interrupting their speed, and giving up the victory. But in the true course of experiment, and in extending it to new effects, we should imitate the divine foresight and order. For God in the first day only created light, and assigned a whole day to that work, without creating any material substance thereon. In like manner we must first, by every kind of experiment, elicit the discovery of causes and true axioms, and seek for experiments which may afford light rather than profit."

From the complicated nature of the phenomena demanding investigation, as well as from the peculiarities of the struggle in which we are now engaged with a powerful enemy, who has blockaded our ports, and cut us off from those implements and materials of research so valuable in modern pathological inquiries, many embarrassments have arisen, and great expenditures of health and strength have been necessary in the prosecution of these investigations.

Generalizations upon the history, origin, and causes of diseases, and their relations to climate and soil, cannot be perfected without *testimony* from various competent medical observers viewing the same diseases under varied circumstances. Thus, such important questions as the contagious or non-contagious nature of typhoid fever and hospital gangrene, the settlement of which would be of interest to the public as well as to the profession, can be determined by no process apart from testimony.

Whilst my entire time and strength will be devoted to the labors indicated in this order of the Surgeon-General, and whilst it shall be, as it has been, my earnest effort to explore in person the most extensive and important fields of investigation, at the same time I desire the coöperation of the medical staff, and cheerfully throw my reports open to the carefully recorded observations of the medical officers of the Confederate army upon the phenomena and relations of diseases.

You can afford valuable assistance by recording observations upon the following disease, and by a careful investigation of the subjects of inquiry now proposed. Even if you should find time from your manifold and pressing official labors, to do nothing more than to faithfully record a single case according to the method here indicated, through the whole course of the disease, it may prove a useful and valuable contribution to medical science; and the discussion of any one of the questions proposed may throw light upon important points in the practice as well as in the theory of medicine.

HOSPITAL GANGRENE.

A. General description of the origin, progress, and characters of hospital gangrene as it has prevailed in the hospital, regiment, corps, or division, or army to which you have been attached.

General description of the origin, progress, and characters of hospital gangrene.

1. What is the date of the first case of hospital gangrene that came under your observation, or to your knowledge?

2. Has hospital gangrene increased or diminished since the commencement of the war?

3. Has hospital gangrene increased in severity since the commencement of the war?

4. Is it possible to trace any relations between the appearance and spread of this disease and the previous exposures, hardships, and changes of climate to which the Confederate soldiers have been subjected?

A general outline of the epidemics of hospital gangrene through which each hospital has passed since the commencement of the war, together with observations upon the effects of climate and soil, water, food, exposure, privations, and severe labors, would prove of great value. Such experience would prove of service in the conduct of future wars.

B. Careful reports of cases studied and recorded through the whole course of the disease at the bedside.

All the phenomena should be carefully observed and noted. The following general plan should be followed in each case: —

Method of investigation and reports of cases.

Description of case.

1. *General Description of Case.* — Name, age, company, regiment, native place, and occupation, color of eyes and hair, complexion and temperament. First symptoms of the disease; time and nature of wound; treatment to which the patient has been subjected; previous exposures; habits and diseases of the patient. All general observations bearing upon the origin and progress of the disease, such as upon the diet, climate, change of climate, hardships in camp and hospital, crowding in cars or badly ventilated rooms and tents, possess value, and should be carefully recorded.

Daily record of symptoms.

2. *Daily Record of Symptoms.* — Date of observation; month; day of month; hour of day; general appearance of the patient; condition of intellect; posture in bed; the grasp of the hand, whether it be strong or weak, uncertain or tremulous; the expression of the countenance, whether it be calm or anxious, or listless, or disturbed; the sound of the voice, whether it be full, firm, or cheerful, or weak, hesitating, and tremulous; the character of the complexion, whether it be healthy, clear, or florid, or pale, sallow, anæmic, or dusky; the state of the nutrition of the body, whether the limbs are full and soft, or full and muscular, or reduced and skeleton-like; the manner of respiration, and the characters of the pulse, should be noted not merely as matters of form, but as of vital importance in furnishing a general outline of the condition of the nervous, circulatory, respiratory, and muscular systems, and of the blood and nutrient energies, and as affording that knowledge which is essential to correct diagnosis and treatment.

Complexion.

Complexion. — The chemical and physical characters of the blood are altered in various diseases, and these alterations are frequently manifested in the change of the color of the blood and its mode of circulation through the capillaries. These changes are especially marked when the process of oxygenation is interfered with, or when certain excrementitious matters, as the coloring matter of the bile, are not eliminated. Changes in the complexion, that is, variations in the color and mode of circulation of the blood in the capillaries of the skin may therefore be important signs of disease, which, if properly understood, enables the sagacious practitioner to determine quickly and clearly the nature of the disease, and the best mode of treatment.

State of wound.

Condition of the Wound. — Careful description of the size and appearance of the wound and surrounding parts. The reaction of the wound should be carefully tested from time to time. In this experiment it is essential that no foreign fluid or body be present. Thus, if the reaction be determined shortly after the wound has been

touched with nitric, acetic, or pyroligneous acids, the reaction will invariably be acid. A sour farinaceous poultice also would give an acid reaction. Microscopical examinations should, if possible, be made of the dead tissues and discharges of the wounds, and careful drawings executed.

Appearance of Tongue. — Clean or coated; pale or red; moist or dry. The appearance of the tongue should be described most minutely. Tongue.

Pulse. — Number of beats to the minute; full or small in volume; forcible or feeble; rapid or slow. Pulse.

Respiration. — Number of respirations to the minute; character of respiration; full or feeble; thoracic or abdominal; natural or labored. Respiration.

Temperature. — Temperature of hand; temperature under the tongue, or in the axilla. If it is possible to secure an accurate thermometer with the bulb exposed, the temperature of the extremities and of the trunk should be determined with the greatest possible accuracy. The hand should completely surround the bulb of the thermometer, every avenue for the entrance of air being closed. It is well to surround the hand with some non-conducting cloth, and to hold the palm and fingers closely around the bulb of the thermometer. The instrument should be allowed to remain until it ceases to rise or fall. When the bulb is placed in the axilla, the arm should be held close against the side and chest so as to surround the stem of the thermometer completely with the naked skin; and the instrument should not be removed for at least half an hour. Temperature.

Condition of Skin. — Dry or moist; soft or harsh; warm or cold; hot or cool. Skin.

Condition of Bowels. — Character of evacuations; number, color, consistence. Bowels.

Urine. — Color; clear or turbid; appearance of deposits. Urine.

Microscopical Character of Deposits. — Amount, abundant or scant. The more recent volumetric method of analyzing the urine, not only yields more accurate results, but is much more rapidly executed than the older and less reliable methods. In the present war we are unfortunately cut off from those countries, as Germany, from which both instruments and reagents could be derived. This is unfortunate, as the field now opened for pathological investigation is more extensive than that ever known to medical officers; and from the very extent of this struggle, which has almost completely emptied the Southern Confederacy of its male population, such an opportunity for investigation will never again be afforded during this generation at least. The importance of examining the excretions of the kidneys cannot be overestimated. As the poisons producing the phenomena of different diseases vary in their chemical constitutions, and in their reactions, and affini-

ties with the elements of the various fluids and tissues, the accurate determination of the amount and characters of the excrementitious compounds resulting from the changes excited by these poisons during different periods of diseases, is of great importance in affording that knowledge by which we may determine not only the tissues specially involved in the pathological changes, but the extent of these changes and their relations to the muscular and nervous disturbances, and to the elevations or depressions of temperature, and thus establish the marked characteristics of different diseases, and aid in the foundation of a philosophical classification of diseases.

To those narrow-minded and ignorant physicians who affect to despise such examinations as unnecessary, disagreeable, and as tending to excite ridicule, we reply in the language of Lord Bacon : —

"With regard to the meanness or even the filthiness of particulars, for which (as Pliny observes) an apology is requisite, such subjects are no less worthy of admission into natural history than the most magnificent and costly; nor do they at all pollute natural history, for the sun enters alike the palace and the privy, and is not thereby polluted. We neither dedicate nor raise a capitol or pyramid to the pride of man, but rear a holy temple in his mind, on the model of the universe, which model therefore we imitate. For that which is deserving of existence is deserving of knowledge, the image of existence. Now the mean and splendid alike exist. Nay, as the finest odors are sometimes produced from putrid matter (such as musk and civet), so does valuable light and information emanate from mean and sordid instances. But we have already said too much, for such fastidious feelings are childish and effeminate."

Blood.

Blood. — In case of hemorrhage, the color and mode of coagulation, form and tenacity of clot, should be carefully observed and noted. Both chemical and microscopical examinations should be instituted. In hospital gangrene it is especially important to determine the proportion of fibrine. Each case under critical examination should be investigated at least twice during the twenty-four hours, and oftener if possible. It is important that the variation of the pulse, temperature, and respiration should be determined at different periods of the day. I recommend that observations instituted with a view to determine the law of these variations be made at 2 A. M., 8 A. M., 2 P. M., and 8 P. M. If only two observations be made during the day, I would recommend the hours 8 A. M. and 8 P. M.

Dr. Thomas Laycock, in his "Lectures on the Principles and Methods of Medical Observation and Research," [1] has given the following interesting observations on horary meteorological, physiological, and pathological changes, which are well worthy of an experimental examination and extension : —

"The hours of the twenty-four in which pathological and physiological changes take place are, in the order of their importance, —

[1] Page 127.

"(*a.*) From 4 to 6 A. M., when the consumption of oxygen by the organism is at the minimum; the thermometer low; the atmospheric pressure low. Death is most frequent at this period; and attacks of epidemic cholera, diarrhœa, ague, and the like, most likely to occur.

Dr. Laycock on the importance of regular observation at stated periods.

"(*b.*) From 8 to 10 A. M. are favorable hours for the health, and the opposite, therefore, to the early morning hours.

"(*c.*) The night hours are appropriate to sleep; and it is during these that diseases seated in the nervous system, or originating there, are the more frequent. The hour of falling asleep is marked by a state of the sensorial system closely analogous to that of morbid states; there is a quasi-delirious condition, predisposing to those paroxysmal diseases which are usually associated with an abnormal circulation of the blood through the brain. It is at this hour that delirium begins in fever and insanity, and that epileptic attacks occur.

"(*d.*) The hour of profound slumber, usually from 1 to 2 A. M., is also characterized by a state predisponent to paroxysmal diseases, but more especially to those in which interrupted excretory function acts on the nervous system; to this group spasmodic asthma, the spasmodic neuralgia, and gout especially belong."

Tables drawn off after the form given upon the next page, will be found useful for the rapid record of the cases.

Each medical officer will find it difficult thus to observe critically and record more than two or three cases each day, together with the regular discharge of his official duties.

In endeavoring thus to investigate and record the phenomena or natural history of any disease, the medical observer will do well to follow the advice of Dr. Thomas Sydenham, in the preface to his celebrated work on "Acute and Chronic Diseases": —

"In writing, therefore, a history of diseases, every philosophical hypothesis which hath possessed the writer in its favor, ought to be totally laid aside, and then the manifest and natural phenomena of diseases, however minute, must be noted with the utmost accuracy, imitating in this the great exactness of painters who in their pictures copy the smallest spots or moles in the originals; for it is difficult to give a detail of the numerous errors that spring from hypothesis, whilst writers, misled by false appearances, assign such phenomena for diseases as never existed but in their own brains; whereas they ought to appear clearly if the truth of their favorite hypothesis, which they esteem incontestable, were well established. Again, if any symptom, properly suiting their hypothesis, does in reality belong to the disease they are about to describe, they lay too much stress upon it, as if nothing more was wanting to confirm it; whereas, on the contrary, if it does not agree with their hypothesis, their manner is either to take no notice at all of it, or barely to mention it, unless they can, by means of some philosophical sub tlety adjust it thereto, and bring it in some measure to answer their end."

Sydenham on the method of medical investigation.

And the medical observer should receive in a like spirit the advice of John Huxham, who more than a century ago drew such faithful portraits of typhus and typhoid fevers, as that modern writers on these

			Name of Patient; Company and Regiment; Date of Wound; Date of Entrance into Hospital; Nature of Wound; Age of Patient; Weight, Height, Complexion, Temperament, Color of Eyes and Hair.
			Day of Month.
			Hour of Observation.
			Condition of Wound; Size of Wound; Color, Characters of Discharge; Gangrene Increasing or Decreasing; Painful or otherwise, etc.
			General Appearance of Patient; Wasted or otherwise; Complexion Clear or Sallow; Posture in Bed; Expression of Countenance, etc.
			State of Intellect.
			Condition of Nervous System; Quiet or otherwise.
			Sleep, Quiet or Disturbed.
			Appetite.
			Appearance of Tongue.
			Condition of Bowels, and Character of Stools.
			Pulse, Number of Beats to Minute; Full, Soft, Feeble, etc.
			Respirations per Minute.
			Temperature of Hand.
			Temperature of Axilla.
			Temperature under Tongue.
			State of Skin, Moist or Soft, Dry or Hot.
			Amount of Urine excreted during Twenty-four Hours.
			Color of Urine.
			Specific Gravity of Urine.
			Characters of Deposits in Urine.
			Reaction of Urine, Acid or Alkaline.
			Urea excreted during Twenty-four Hours.
			Uric Acid excreted during Twenty-four Hours.
			Free Acid excreted during Twenty-four Hours.
			Phosphoric Acid excreted during Twenty-four Hours.
			Sulphuric Acid excreted during Twenty-four Hours.
			Chlorine excreted during Twenty-four Hours.
			Equivalent, Chloride of Sodium.
			Soda.
			Potassa.
			Lime.
			Lactic Acid.
			Ammonia.
			Creatine.
			Creatinine.
			Albumen.
			Extractive and Coloring Matters.
			Characters of Blood; Proportion of Fibrine, etc.
			Treatment.
			Remarks.

FORM OF TABLE FOR THE RAPID RECORD OF CASES.

diseases have added but little either to his description of the symptoms during life, or to the principles of treatment which he laid down. In the preface to his "Essay on Fevers," after recommending the study of the works of the ancients, and especially of Hippocrates, and after extolling the ancients not only as men of vast genius but of the greatest diligence and unwearied application, who kept their eyes steadily fixed on what they would describe, and thus gave us the true picture and naked truth of things, which is infinitely more beautiful than all the affected daubery and flourishes of a modern luxuriant imagination, Huxham forcibly remarks: —

"The more just the description, always the more excellent. What is a portrait good for, that is not like the original? As Nature herself, the more accurately viewed, is the more admired, so he that gives us the truest copy of her face will ever be deemed the greatest master. In this, Hippocrates so greatly excelled, that he had the united applause of the nations around him, nay, they even paid him divine honors; for by this he was enabled to heal as well as to know and describe diseases. I am fully persuaded, had his method been strictly followed by succeeding physicians, the art of healing would have long ere this time been carried to a much greater height than it is at present, which hath by no means kept pace with the many and great discoveries that have been made since, especially within this and the last century, in natural philosophy, anatomy, the materia medica, and chemistry. Indeed, as man is by nature mortal, it is impossible that art can make him immortal; but surely it is very possible it may supply something more exact and determinate than we have at present."

The following questions demand careful investigation: —

C. Is hospital gangrene a local or constitutional disease?

Hospital gangrene local or constitutional.

1. Do fever and constitutional disturbances invariably precede hospital gangrene?

2. Do fever and constitutional disturbances invariably accompany hospital gangrene?

3. Is hospital gangrene ever strictly local in its effects without any constitutional disturbances?

These questions can be best decided by keeping a careful record of all the phenomena, and especially of the changes of temperature and urine, throughout the whole course of the disease. The investigation should, if possible, be commenced before the appearance of the gangrene.

The effects of amputation in arresting the disease or otherwise, should be carefully noted, as bearing directly upon the definite settlement of the question of the local or constitutional origin of the disease.

D. Is hospital gangrene contagious?

It is difficult to settle the question of contagion, and it is still more difficult to define its laws.

Question as to the contagion of hospital gangrene. Points to be observed in this discussion.

It is incumbent upon those who assert the contagious or non-contagious nature of hospital gangrene, to give the cases and facts upon which their belief rests. Mere opinion can possess but little value in the determination of complicated questions. In attempting to isolate patients in the same hospital, it is almost impossible to avoid the numerous sources of contagion, and strictly isolate the wounded under observation and experiment: the basins, the towels, the water, the rags, the mingling of the bed-clothes in washing, or even the flies, may one or all be sources for the transmission of gangrenous matter from one patient to another. Then there is the medium of the atmosphere for the transmission of various gases. In the crowded wards of the hospital, the atmosphere may become poisoned by the exhalations of the lungs and skin, and of the urinary and intestinal excretions; and the general system of all the patients be affected by the absorption of these poisons. The cases of typhoid fever and other diseases are rendered more severe and fatal by these depressing agents, whilst the general health of the wounded is affected by the blood poisoning, and the most marked and dangerous effects are manifested in the place of injury.

In hospitals crowded with wounded, the oxygen, and especially that active state of this element known as ozone, may be consumed to such an extent, that the wounds may assume an unhealthy appearance from the imperfect oxygenation of the blood, and the consequent derangement of the chemical and physical constitution of the blood and nutrition of the tissues.

It is a matter of importance to determine how far hospital gangrene may be due to changes in the physical and chemical properties of the atmosphere apart from the introduction into the surrounding medium of poisonous agents. The direct effects of different gases, as hydrogen, nitrogen, sulphureted hydrogen, and ammonia, upon gunshot wounds, apart from any action through the general system, should be carefully investigated; and we may reasonably look to the results of such an investigation as likely to establish valuable principles, both for the treatment and the prevention of hospital gangrene.

"Contagion" used in its most general acceptation, and as synonymous with infection.

I have used the word contagion in its most general acceptation, and as synonymous with infection; that is, the communication of disease in any way from one person to another without reference to time, or medium of communication. Literally contagion[1] means a touch or touching, and hence the attempt by some writers to confine the meaning of this word to the communication of disease by contact.

Infection[2] means to thrust in, and may, without doing any violence to the derivation and literal meaning, be made to signify the direct infu-

[1] Lat. *contagio*, from the root of *contingo*, *tango*, primarily *tago*, to touch.
[2] Lat. *inficio*, *infectus*, *in* and *facio*.

sion into a healthy body of some virus or morbid matter from a diseased body, or the infusion into the body of some deleterious miasmata from the surrounding medium. The poison of some diseases, as syphilis, can be infused into the healthy body only by direct contact, whilst in others, as measles and small-pox, the poison may be infused into the surrounding air and the healthy body brought under its influence, and the original disease be communicated and reproduced, without direct contact with the living body. Literally, therefore, infection is a generic term embracing both the idea of the communication of disease by contact (contagion), and the transmission of disease through the surrounding medium. As the word contagion is destitute of the verbal form, the phrases to infect, or to be infected, become convenient modes of expression. It is evident, therefore, that it would be entirely arbitrary to limit the meaning of infection to the communication of disease from the sick to the healthy, by a morbid miasm or exhalation diffused in the air. Neither are we justified in limiting the term contagion to the communication of disease by the actual touch of diseased and healthy bodies; for the atmosphere is a porous form of matter, as well as the clothing of the sick, and besides this the water diffused in the form of vapor through the air, becomes a medium for the absorption and direct application of morbid matters to the surface of healthy bodies.

The use of the words contagion and infection as synonymous should not lead to confusion, but should rather lead to farther investigation; and when the laws of the transmission of diseases are better understood, we shall have increased accuracy of description, expression, and a more perfect nomenclature; and it will be seen by the succeeding inquiries that we desire by the employment of these terms in the most general sense, to avoid the chief fault of distinctions drawn between infection and contagion, which have generally been based upon preconceived, narrow, and erroneous views of their nature and operation.

Sir Henry Holland on the method of inquiry as to contagion.

The observations of Sir Henry Holland upon the "Method of Inquiry as to Contagion," in the third chapter of his "Medical Notes and Reflections,"[1] are worthy of the most careful consideration of those who may seek to determine its laws: —

"I believe it may be assumed, that in every instance of communicated disorder of the same kind (except the ambiguous case of certain nervous complaints, when other principles are concerned), there is a *materies morbi*, — a material cause, — whatsoever and howsoever subtle its nature and manner of transmission, which is directly concerned in the communication. This assumption, though large, is justified by observation as far as it goes; by strict analogy and probability, when observation cannot be had. It is likely that future research will rather augment than lessen the number of instances when such miasma or material cause of contagion may be presumed to exist. And it is further probable, that we shall hereafter acquire more intimate knowledge of

[1] Pages 58–62.

the nature of these morbid matters; of their relations to each other, and the manner in which they are transmitted so as to propagate disease. The course of modern inquiry directs through many channels to these important results.

"Looking singly, however, to the principle just stated, and admitting its truth, we shall find basis in it for all reasoning on the laws and anomalies of contagion; that is to say, for all the conditions which determine and modify the communication of disease from one person to another. A disease is communicated by some morbid matters, thrown off from the first, and capable of producing like symptoms in the second, when conveyed either by inoculation, by simple contact, or indirectly through some medium of transference. Here, then, three main conditions present themselves, each open to many variations, and in their combination capable of producing the numberless varieties and apparent anomalies in the laws of contagion. These conditions are, — first, the state of the person giving the infection; secondly, the state of the person receiving it; thirdly, the condition of the medium through which the transference is made. I believe that reflection will show the whole subject to be comprised under these three heads; and that we are bound to refer to them severally in all particular questions or instances which come before us for solution.

"The first is very important, inasmuch as it includes all that relates to the varying quantity and intensity of the virus itself. This forms a part of the condition of the patient giving the infection, and the most essential part; one, however, by no means duly appreciated in the ordinary methods of viewing the subject. Though we have no present method of estimating either the absolute quantity, or the energy of quality, of the material cause, or the relation which these conditions bear to one another, this does in no wise lessen the certainty that variations exist in different cases, and have effect, directly or indirectly, in every example of infection. In the case of inoculated disease, we have evidence as to this point, from the influence of dilution in altering or annulling the effects of the virus employed. The modifications arising from the particular period of the disorder, from idiosyncrasies of constitution in those affected, and especially from the variety of the part or textures through which communication takes place, are all concerned in this view, and have severally their influence in determining the power of the virus, and the course of propagation of the disease.

"Under the second head, namely, the state of the person receiving the infection, we have modifications derived from the previous condition of temperament and general health, from the actual health at the time, and particularly from the presence or absence of other specific disorder, counteracting or modifying the virus received; and from the state of the organ or tissue first or most intimately affected by it. All these circumstances needfully enter into a just and complete view of the subject; but none of them, as I think, are sufficiently regarded in our common methods of dealing with it. The latter point in particular has been almost wholly kept out of view, from the great difficulty of reaching it by any distinct proofs. Yet we cannot for a moment doubt that the condition of the part which habitually or casually receives any given infection, must determine the degree of the effects produced, and probably in many other ways modify their character and course.

"Under the third head, of medium of transmission, still more numerous variations may be presumed to exist. Putting aside the obvious cases of inocu-

lation, and contact of surfaces, and looking to the atmosphere as the medium in the great majority of instances, we have here the endless variety arising from changes of weight, temperature, humidity, electrical state, and direction of currents, — circumstances ever fluctuating in themselves, constantly changing in their combinations with each other, and capable therefore of modifying infinitely the action of any virus thus conveyed, even without regard to the chemical changes which it may possibly undergo during transmission. And further under this head, we have the case of fomites or virus thrown off from diseased surfaces, imbibed by porous bodies, and again emitted — occasionally, as some assert, in a more concentrated form, from this previous absorption.

"Duly considering these several points, they will be found, I think, to show adequate cause for all the strange and perplexing appearances of contagious disease. So far from being difficult to explain why a given disorder should occasionally appear infectious, at other times not; why it should spread rapidly and virulently in some localities, and not at all in others; why it should affect some persons, and leave others free; why the cases should be violent at one period, mild at another, — it is rather, perhaps, matter of wonder that the circumstances are not still more varied and irregular than we find them to be. When there are such numerous and ever-changing elements of difference, the combinations of these may well give scope to every assignable variety of result. It is clear that very many of the contradictions of opinion and statement, as to the contagious nature of certain diseases, may be solved by a reference to these considerations. In all common reasoning on the subject, and even in what has been written upon it, infection is too much regarded as a simple and uniform act, and the virus transmitted as the same in quantity and intensity. Such views, however, carry error into every part of the discussion. If we can dilute the matter of small-pox, so that it is no longer capable of giving the disease by inoculation, equally may the effluvia of certain fevers, capable of communicating the disorder in one degree of concentration, be so diluted in other cases, — either in their original emissions from the sick body, or by distance, or from the state of the atmosphere, or by the intervention of other matters, — that they lose their power of reproducing disease in its complete and specific form. Accordingly we find that in these fevers, as well as in diseases more undoubtedly and actively contagious, the proofs of infection multiply in proportion as the causes exist which are likely to concentrate, or give direction to infectious matter; as stagnant air, want of cleanliness and fresh clothing, proximity of place, particular currents of air, etc. And what is true as to these disorders, will equally apply to many other doubtful or anomalous cases in the history of disease.

"In erysipelas, for example, though its occasional contagious nature is sufficiently proved, the instances of this are comparatively so rare that it occurs in the light of an anomaly to common observation. The controversy still existing as to infection in puerperal fever, may probably best be solved by a close regard to the circumstances stated above. Nor can I doubt (having seen cases which go far to prove it) that a patient laboring under genuine measles may be present to another, perfectly susceptible of the infection, without the latter receiving the disorder, in default of the quantity or other peculiar state of the virus, needful for its passage through the intervening air. And this point receives farther illustration from those singular cases where an imperfect and irregular evolution seems to occur of an infectious disorder, the actual nature and pres-

ence of which cannot be doubted. These various conditions can in no way be so well explained as by looking to the difference in quantity or concentration of a given virus, and to the manner of its introduction into the system; diversities which must be of constant occurrence, and can never occur without some change of effect.

"It is another and frequent mistake, in reasoning upon contagion, to consider that the infectious nature of a disease may be disproved, by showing that it has been spread without any obvious communication through man or human means. The two conditions brought into the question, instead of being opposed, are, in fact, perfectly compatible with each other. If a virus can be transmitted from the body through a few feet of air, we are not entitled, from the partial experiments hitherto made, to set any limit to the extent to which, under favorable circumstances, it may be conveyed through the same or other medium.

"This virus, as already stated, must in every case be regarded as a *material agent*, and, as such, susceptible of various influence and modification. Common reason here concurs with our actual experience of the transmission of the virus of certain diseases in various ways, and to remote distances."

E. IF HOSPITAL GANGRENE BE CONTAGIOUS, HOW IS IT TRANSMITTED — THROUGH THE ATMOSPHERE, OR BY DIRECT CONTACT AND INOCULATION?

Question as to the mode of transmission of hospital gangrene.

In the determination of such questions, all cases where healthy nurses and surgeons have been inoculated by the gangrenous matter, should be carefully recorded. Each case of inoculation by gangrenous matter should be considered as a valuable experiment.

1. Will hospital gangrene appear in healthy men with only slight wounds, who are exposed only occasionally and at short intervals to the atmosphere of the patients suffering with the disease?

2. Can hospital gangrene be communicated to a strong, healthy man, simply by inoculation, the subject of the experiment being removed entirely from the atmosphere of the hospital?

3. Does the constant inhalation of the atmosphere of a hospital predispose to hospital gangrene?

4. Can the general system be influenced, by the atmosphere of wards crowded with patients suffering with hospital gangrene, to such an extent that the disease may appear without any known local injury, manifesting itself in sound parts?

5. Does hospital gangrene ever arise spontaneously in a well-ventilated room or tent, removed entirely from all other collections of human beings? Thus, does hospital gangrene ever arise when only a single wounded man occupies a well-ventilated house, where there are no other sick and wounded, and no collection of living beings?

F. WHAT ARE THE ESSENTIAL CONDITIONS AND CAUSES OF HOSPITAL GANGRENE?

1. Do previous exposure, bad diet, and fatigue predispose to the disease?

2. Will hospital gangrene arise spontaneously amongst men crowded, as prisoners are, into confined spaces, and subjected to various depressing influences, as mental distress, bad diet, foul air, and filth? Questions as to the causes and conditions of hospital gangrene.

3. Does the transference of the wounded after battles, in close cars to a great distance, predispose to hospital gangrene?

4. Has climate any influence in the origin and spread of the disease? Is a low, malarious climate favorable to its origin and spread? Has moisture any connection with the origin and spread of the disease? Can any connection be traced in hospitals between the condition and changes of the gangrenous wounds and the changes of the weather?

These questions open a wide and interesting field of inquiry, and the discussion might be rendered important and interesting by a sketch of the campaigns, the hardships, exposures, and depressing influences and changes of climate to which the soldiers have been subjected previous to the prevalence of hospital gangrene. The inquiry respecting the influence of climate upon the production and modification of hospital gangrene, should embrace, —

First, Investigations into the chemical constitution of the air. The proportions of ozone, carbonic acid gas, sulphuretted hydrogen, ammonia, and of all noxious gaseous admixtures, should be carefully determined.

Second, The changes of weight or density.

Third, The changes of temperature.

Fourth, The hygrometric state.

Fifth, The electrical state and changes.

Sixth, The physical and chemical actions of the rays of the sun, not merely upon the atmosphere during their transmission, but upon living vegetables and animals, and upon dead animal and vegetable matters. Thus it is a well-established fact that there is a greater proneness to diseases, especially of a low form, in those parts of crowded buildings, such as barracks, from which the light is excluded; and Dr. Reid, of Edinburgh, has inferred from experiment that the effects produced by an atmosphere loaded with the excess of carbonic acid, are more speedily removed when the patient is placed under a strong light, than when merely brought into fresh air.

G. ARE THERE ANY LESIONS RECOGNIZABLE AFTER DEATH WHICH ARE CHARACTERISTIC OF HOSPITAL GANGRENE?

This question can be settled only by careful post-mortem examinations.

Questions as to the characteristic lesions of hospital gangrene.

1. In each examination, we should dissect the parts in and around the wound most carefully, and examine with special minuteness the blood-vessels and nerves. The contents of the blood-vessels, with the characters of the fluids, pus or blood, which they contain, should be carefully noted.

2. Is the diarrhœa which so often appears in the latter stages of hospital gangrene, dependent upon any uniform alteration of the mucous membrane of the intestinal canal?

3. Is the spleen enlarged and softened in fatal cases of hospital gangrene?

4. Is pyæmia more common in patients suffering with gangrenous wounds than in ordinary wounds free from hospital gangrene? In all fatal cases of pyæmia, careful examinations should be instituted of the blood-vessels in and around the diseased parts.

5. Do the blood-vessels ever contain pus in pyæmia?

6. When the veins contain pus in pyæmia, is its progress towards the heart barred by the formation of clots, where the pus and blood meet?

The points of interest to be determined in such cases are, —

First, The contents of the veins and arteries.

Second, If they contain blood, is this invariably coagulated near and in the diseased structures? What are the characters of the coagula — coagulated blood, or fibrin devoid in great measure of its colored corpuscles?

Third, In cases of pyæmia, do the veins entering the diseased structures contain pus? When they contain pus, is it secreted by the veins, or absorbed directly from the diseased structures through the eroded and open coats of the veins?

H. WHAT IS THE BEST MODE OF TREATING HOSPITAL GANGRENE?

Questions as to the treatment of hospital gangrene.

1. What is the relative value of nitric acid, and the actual cautery in the treatment of the disease?

2. Value of turpentine, and method of application?

3. Can severe cases of hospital gangrene be treated successfully without local treatment?

4. What is the best method of constitutional treatment?

5. Can hospital gangrene be treated strictly as a constitutional disease, without any local application, with success? In the determination of this question, no local application should be used.

6. Can hospital gangrene be treated with success, strictly as a local disease, without any constitutional measures, especially in the crowded hospital, and in the present condition of the Confederate troops?

7. Is the combination of local and constitutional treatment the best method?

8. What have been the results of amputation in hospital gangrene?

9. Does amputation ever arrest hospital gangrene, and what are the conditions of the constitution most favorable to its arrest by amputation?

10. What are the conditions which warrant amputation in hospital gangrene?

11. What is the best method of arresting hemorrhage in this disease? What are the conditions in which ligation is preferable to the application of styptics? As a general rule, what is the best point for ligation in hospital gangrene — within the wound, or in the sound parts? Has pressure any value in the arrest of hemorrhage in hospital gangrene? When the patient survives the hemorrhage, is it generally followed by improvement in the gangrenous wound?

12. Are limbs ever restored, so as to be capable of active service in the field, in which gangrene has made extensive ravages? What is the proportion of cures to the permanently disabled in this disease?

13. What is the best form of diet in the treatment of hospital gangrene?

All these questions are open for discussion and investigation, and can be settled only by the most careful study and record of the cases.

It would be best when hospital gangrene is prevailing, to examine carefully the phenomena presented by all the wounded, whether suffering from the disease or not. In this way alone could the question of the constitutional or local origin be determined.

Experiments with the gangrenous matter might be instituted upon animals and even upon man.

Allow me to assure you that I will take great pleasure in considering carefully any observations which you may record and forward me upon these various subjects of inquiry, and in presenting in your name the cases and facts of interest in my reports to the Surgeon-General.

And in conclusion I would again, in the language of Bacon, express my belief in the great value of careful observations over mere dogmatic expressions of belief and opinion, unsupported by facts, although such assertions may be dignified by the title of *extensive* experience: —

"They who have presumed to dogmatize on nature, as on some well-investigated subject, either from self-conceit or arrogance, and in the professional style, have inflicted the greatest injury on philosophy and learning. For they have tended to stifle and interrupt inquiry exactly in proportion as they have prevailed in bringing others to their opinion; and their own activity has not counterbalanced the mischief they have occasioned by corrupting and destroying that of others.

"The human understanding resembles not a dry light, but admits a tincture of the will and passions, which generate their own systems accordingly; for man always believes more readily that which he prefers. He therefore rejects the difficulties for want of patience in investigation; sobriety because it limits his hope; the depths of nature from superstition; the light of experiment from

arrogance and pride, lest his mind should appear to be occupied with common and varying objects; paradoxes from a fear of the opinion of the vulgar; in short, his feelings imbue and corrupt his understanding in innumerable and sometimes imperceptible ways.

"There is no small difference between the *idols* of the human mind and the *ideas* of the divine mind; that is to say, between certain idle dogmas and the real stamp and impression of created objects, as they are found in nature.

"Man, as the minister and interpreter of nature, does and understands as much as his observation on the order of nature, either with regard to things or the mind, permit him, and neither knows nor is capable of more."

Very respectfully,

Your obedient servant,

JOSEPH JONES,
Surgeon P. A. C. S.

In the present volume, the results of observations upon more than one thousand cases of hospital gangrene will be recorded. The subjects of investigation will be presented under the following general divisions: —

First, The description of the phenomena of the disease, embracing the local and constitutional changes, the microscopical appearances of the gangrenous matter at different periods, the constitution and changes of the blood and urine, the variations of the pulse, respiration, and temperature.

Second, The causes of death, and the pathological changes.

Third, The causes of hospital gangrene, embracing an examination into the relations of foul air, exposure, diet and climate, to the origin and progress of the disease.

Fourth, An effort to form such a theory of the disease as will embrace the known facts.

Fifth, Relations of hospital gangrene to various diseases.

Sixth, Treatment.

Each of the preceding divisions will be illustrated by cases.

Seventh, The views and labors of Confederate surgeons upon hospital gangrene.

DEFINITION OF CERTAIN TERMS.

Definition of certain terms.

From the commencement of the war for the independence of the Confederate States of America to the middle of 1864, the form of "Reports of the Sick and Wounded" was similar to that employed in the old United States service.

Impossible to determine from the

The term *gangrene* does not appear in this classification of diseases. A new form of sick report, containing a different classification of diseases, was issued about the middle of

1864 (the first reports upon this new form returned from the general hospitals of the Army of Tennessee were for the month of July, 1864); and gangrene appears for the first time in the Confederate list of diseases.

Confederate sick reports the time of origin or number of cases of hospital gangrene.

It is impossible, therefore, to determine from the sick reports of the Confederate armies, either the date of the origin, or the number of cases of gangrene.

In the new classification, under the general division of "Non-inflammatory Diseases, but frequently attended by Inflammation during their Course," and under the subdivision "Diseases with their Seat in the Skin and Cellular Tissue," we find the terms *gangræna sicca*, *gangræna humida*, and *phagedæna gangrænosa*, laid down as if they were three distinct and specific diseases, in immediate connection with, and under the same general division and subdivision with scabies, eczema, impetigo, psoriasis, urticaria, lepra, herpes, anasarca, ulcers, and fistula in ano.

Observations upon the new form of sick reports and classification of diseases, adopted by the medical department of the Confederate army.

It is thus implied, if not directly asserted, that *gangræna sicca*, *gangræna humida*, and *phagedæna gangrænosa* are not only three distinct specific diseases, but also that their seat is in the skin and cellular tissue, that they are essentially local diseases, as certain skin affections and fistula in ano, and that they are not necessarily accompanied with inflammation; or more accurately, that these forms of gangrene, as well as the long list of diseases included under the same general division, are in their nature "non-inflammatory, but frequently attended with inflammation during their course."

Upon a still farther examination, it will be seen that "erysipelas traumaticus" is included under the same general division of "Non-inflammatory Diseases, but frequently attended by Inflammation during their Course," and is classed under the subdivision "Accidents, Injuries, etc.," alongside with "contusio, vulnus incisum, vulnus laceratum, vulnus punctum, vulnus sclopeticum, luxatio simplex, luxatio composita, fractura simplex, fractura composita, sub-luxatio, prolapsus ani, hernia inguinalis, hernia femoralis, concussio cerebri, compressio cerebri, suicidium, asphyxia, hanging, drowning, irrespirable air, military execution," whilst on the other hand "erysipelas idiopathic" appears under the head of "continued fevers, the seat of which is referred to the blood, as febris cont. simplex, febris typhoides, typhus, febris typhus icterodes, rubeola, variola, varioloides, scarlatina simplex, scarlatina anginosa, and scarlatina maligna."

We might dwell upon the fact that the seat of the various forms of malarial fever is in this classification referred exclusively to the nervous system, whilst it is now well established that the blood is more thoroughly altered in its physical and chemical constitution in malarial fever than in any other form of disease, except perhaps in pyæmia, which is preëminently a blood disease, and which resembles in many of its phenomena so nearly certain forms of malarial fever; and we might notice, still further, the omission of the most common of all army diseases, dysentery, acute and chronic (it is true that colitis acuta and chronica appear in the classification, but these terms should not include the more generic name of dysentery, as in this last disease other organs besides the colon may be both primarily and secondarily involved); but we desire merely to present such facts as indicate the necessity of the careful definition of such terms as mortification, gangrene, sphacelus, dry gangrene, moist gangrene, hospital gangrene, gangrenus phagedæna. A correct idea of the meaning of mortification, gangrene, sphacelus, dry gangrene, and moist gangrene, will best be obtained by a brief examination of the manner in which these terms have been employed by some of those systematic writers whose works may be taken as exponents of the state of medical science at the period at which they were written.

Galen's definition of gangrene.

Galen defined gangrene to be a mortification not actually formed, but forming, being the intermediate stage between the height of inflammation and the state of sphacelus, or complete death.

Mode in which the term gangrene has been employed by various writers.

Various writers, as Fabricius Hildanus, John Baptist Morgagni, Matthew Baillie, William Cullen, John Abernethy, and Charles Bell, have employed the terms gangrene and sphacelus in pretty much the same sense in which they were used by Galen.

In the treatise of Samuel Sharpe, "On the Operations of Surgery," the tenth edition of which was published in London in 1782, it is affirmed that inflammations from all causes have their ways of terminating, either by dispersion, suppuration, or gangrene; and the terms gangrene and mortification are used as synonymous.

Percival Pott, in his "Chirurgical Works," uses the term mortification in a generic sense, and applies it to the entire phenomena of gangrenous inflammation and death of parts.

John Hunter divided mortification into two kinds, the "one without, the other with inflammation."

"The effects of life are preservation and action; death is the loss of both. Life may exist in the whole, or only in a part, but it must always be in a vital part. Other parts may be dead, without affecting materially the machine. The immediate cause of death in a part would appear to be a loss of circulation; this may arise in various ways, but it must be the effect of some cause. Mortification is very different from universal death; the loss of natural life arises from some universal action having taken place, the same structure still remaining; but it is altered in mortified parts, all is blended in one mass of animal matter, and cannot possibly be injected.

John Hunter divided mortification into two kinds, the one without, the other with inflammation.

"Partial death, or mortification, arises from various causes; yet there is probably in all of them some cause which may be called specific. There are many others which may be considered as immediate and remote causes, as happens in the gout, which may be produced by many causes, yet the specific cause has a peculiar mode of action in this as it has in other diseases. Mortification is commonly attended with great pain, characterized by burning, and, if it is in view, the stagnation of blood in the vessels always produces a livid color. The same burning sensation takes place from pressure, if carried sufficiently far to produce mortification, and is familiar in people's heels after lying long in bed.

"There are two kinds of mortification, one without, the other with inflammation.

"The first arises from causes less visible than the other; that is, there is no increased action or sensible heat, although the burning pain is considerable. What the predisponent cause is I cannot tell; I have suspected something like a spasm of the small vessels, but I cannot be certain; we know spasm will sometimes threaten mortification, as we see in priapism, by which I have seen mortification produced in a dog. When the disposition is present, the action goes on; as we see in sores, some parts being of a purplish hue, and going on in this way, while health is in the other parts. In some of these cases a part withers and dies, and does not stimulate the living parts, so as to produce separation, for a long time; but I have seen too few of these cases to judge of them accurately. The second kind seems to arise from a change taking place before death. Inflammation seems to be the immediate cause; but this inflammation has two remote causes, of which one is weakness, which is the common cause of mortification; but the other, or that which produces carbuncle, is not well known.

"Inflammation sometimes depends upon an increased action, with increased power of the vessels; but in mortification it must depend on an increased action with diminished power; in all cases where this kind of mortification takes place, we have evidently a deficiency of the animal powers. In young people, mortification is generally preceded by fever,

in old by debility; and the weakest parts generally give way first, as the toes. But debility alone does not produce mortification, if there happens to be strength in the part sufficient for the action which is induced: debility, therefore, is only a predisposing cause. We see this in scarifying anasarcous legs, in weakness from accident in weakened parts, in bruises, in frost-bitten parts, or wherever action is produced beyond what the powers of the part or system are able to sustain. But the increased action is not necessarily inflammation; it may be a salutary endeavor of the part to restore itself, which salutary action the powers of the part cannot support, and hence it gives way and dies. When frost-bitten parts are exposed to heat, the debility is increased by the necessary action, which action the strength of the part cannot bear. Heat is congenial to life, but it should be proportioned to the degree of life, or otherwise it will increase the debility. On this principle it is that cold air is so serviceable to people weakened by disease. In frost-bitten parts, for example, the living principle is much diminished by the previous cold, and heat must be gradually applied, in proportion to the quantity of life which remains, but as the manifestations of life increase, so should the heat be increased also; otherwise, by applying a degree of heat at once too great in proportion to the life, the part will mortify, which is invariably the case in man and all other animals, for warmth induces a more than ordinary exertion of the living powers, which may even be so considerable as to destroy the powers themselves.

"Parts which have been weakened, seem much disposed to take on the continued sympathy; and the parts, finding this disposition, become irritable, and are easily inflamed, which inflammation produces death oftener than any specific inflammation. Mortification, however, is neither peculiar to weakened habits nor accidents, but is often consequent on common inflammation, as in compound fractures. In a state of health, the powers are much greater than the action; but when this state does not exist, either the powers or the action must be predominant. Thus in mortification the powers are too weak for the action; but this weakened power is produced by various causes, such as old age, accident, or erysipelas. The skin of such as take on this irritable action, is generally opaque, and looks withered even in the young subject."[1]

Mr. Hunter, therefore, viewed inflammation as an increased action of that power which a part is naturally possessed of; and in those inflammations which he denominated healthy, this increased action is attended with an increase of power; but in inflammations which result in mortification, there is no increase

[1] *The Works of John Hunter, F. R. S.*, with notes; edited by James F. Palmer. London, 1837. Vol. i. "Lectures on the Principles of Surgery," p. 602.

of power, but on the contrary, a diminution of power, which, joined to an increased action, became the cause of mortification, by destroying the balance which ought to subsist between the power and action of every part.

John Pearson, whose "Principles of Surgery" were published in 1788, about five years before the death of John Hunter, whilst adopting the definition of the older writers, that "a gangrene, strictly speaking, is a mortification not actually formed, but approaching, being the intermediate state between the height of inflammation and sphacelus," at the same time dissents from the custom of many writers to enumerate gangrene as a third mode in which inflammation frequently terminates, and affirms that there is not a necessary connection between the two diseases. "Gangrene does indeed some times supervene to inflammation, but this order is not absolute and immutable, for it very often originates from causes which imply a state of the system that is the reverse of inflammation."

John Pearson taught that there was not a necessary connection between gangrene and inflammation.

This writer used the term mortification as synonymous with sphacelation, and drew a clear distinction between this last word and gangrene. Thus: —

"As a gangrene most commonly terminates in sphacelation, there is some propriety in treating both of them under one head; yet the difference between a gangrenous and mortified part is so very considerable that the terms ought never to be employed as synonymous ones.

"A part of the body that is afflicted with gangrene, does not immediately lose its sensibility; the fluids continue to circulate in their vessels, and within certain limits the part is capable of being restored to its former offices in the animal economy. Sphacelation implies the total loss of life in the part; an absolute derangement of its structure; the ablation of all its functions, and an utter incapacity of its being restored to any service in the animal economy."

Amongst the remote causes that have a powerful influence in producing gangrene, Pearson enumerates, —

1. The application of severe stimuli to a diseased or debilitated part, as in the effects of lightning, intense inflammation, erysipelas, the action of aerial substances, poisons, fractured bones, etc., and strong stimulants applied to dropsical or paralytic limbs.

2. Obstruction to the due transmission of blood, especially when there is an increased action in the blood-vessels; as in strangulated hernia, tight bandage, compression of large blood-vessels by tumors.

3. A sudden diminution of sensibility and repression of action in a diseased part, by the improper application of repellant remedies, as is sometimes seen in erysipelas, etc.

This author again divides the causes which may induce sphacelus into four divisions: —

1. Whatever destroys the organization of a part, so that it becomes incapable of carrying on its natural functions, as in large wounds, when the most considerable blood-vessels of a part are divided, violent contusion, by which the contexture of a part is subverted, and the contents of the vessels are either effused or rendered incapable of being circulated.

2. Total obstruction to the motion of the blood in a principal artery, as in some cases of aneurism, ossification of arteries, compression from tumors, etc.

3. Certain changes induced upon the living solids and fluids, by cold, heat, actual and potential, and also from the use of unwholesome food.

4. Sphacelation sometimes appears suddenly, without any evident procatarctic cause.

The previous state of the general system has very extensive influence in determining the action of the remote cause to the production of gangrene or sphacelus, as previous fever, dropsy, paralysis, and languid action of the extreme blood-vessels, as in old age.[1]

The division of mortification into two kinds, "the one without and the other with inflammation," proposed by John Hunter, was adopted by various systematic writers on surgery, as Samuel Cooper, in his "Dictionary of Practical Surgery," and John Syng Dorsey, in his "Elements of Surgery," and John Abernethy, in his "Surgical Works" and "Lectures on Surgery." Charles Bell, in his "System of Operative Surgery founded on the Basis of Anatomy," affirms that he had not seen gangrene the consequence of high inflammatory action: "it should rather be called high irritation, which disorders and overcomes the inflammatory action, and is followed by mortification."

The division of mortification into two kinds, by John Hunter, adopted by various systematic writers.

Sir Astley Cooper, in his "Lectures on the Principles and Practice of Surgery," uses the term gangrene in a generic sense, and defines it to be a partial death, — the death of one part of the body, while the other parts retain their natural powers.

1 *Principles of Surgery, for the Use of Chirurgical Students*, by John Pearson, Surgeon. London, 1788. Part I. pp. 108–112.

"We find that when inflammation is extremely violent, it occasions the destruction of the vital power of the part. At other times, when there is a less degree of inflammatory action, but the powers of the part are feeble, life will still be destroyed; so that gangrene is produced either by an excess of inflammatory action, where the powers are natural, or by a less degree of inflammation, where the powers of a part are feeble. . . . . The nature of gangrene, as far as dissection enables me to judge of it, is this: the excessive action of the part kills the blood-vessels, and the blood contained in dead vessels becomes coagulated."

Sir Astley Cooper uses the term gangrene in a generic sense.

As the term gangrene was found to be not sufficiently expressive of the different varieties of mortification, it was further subdivided by several of the authors just referred to, and by many others, into idiopathic, chronic, or dry gangrene, when the death of the part has been preceded by little or no deposition of fluids in it, and followed by a drying and hardening of the part with few signs of putrefaction; and humid gangrene, when the death of the part has been preceded by a great deposition of fluids in it, and followed by rapid and general putrefaction.

Gangrene farther subdivided into dry and moist, or humid.

John Thomson, in his "Lectures on Inflammation," employed mortification as a generic term, comprehending the whole series of phenomena which occur in any inflamed texture or organ, from the first apparent diminution of its vital powers to their total and complete extinction. As a considerable interval of time often elapses, and many marked events may occur, between the state of apparent diminution of the vital powers of an inflamed part and the complete extinction of life, the term gangrene has been employed by Thomson and many others to express that stage of mortification in inflamed parts which precedes the death of the part, and the word sphacelus to denote the complete death or mortification of a part. As thus employed, gangrene relates to the stage in which there is a diminution, but not a total destruction of the powers of life; in which the blood appears to circulate through the larger vessels; in which the nerves retain a portion of their sensibility; and in which, perhaps, the part affected may still be supposed to be capable of recovery; and sphacelus denotes that state in which the blood ceases to circulate, the sensibility of the nerves is lost, and the powers of life have become extinct, whether the dead or mortified part has or has not become actually putrid, or shown any tendency to separate and fall away from the living and sound parts.

John Thomson employed mortification as a generic term, comprehending the whole series of phenomena which occur in any inflamed texture or organ, from the first diminution of the vital powers to their total extinction.

Putrefaction, or the spontaneous decomposition of the animal tissues, has been regarded by many writers as an accidental, and not a necessary effect of the state of mortification; because the period at which it occurs, as well as the extent to which it progresses and the rapidity of its progress, are regulated by the structure and morbid conditions of the dead tissues, and by external circumstances, as the temperature and humidity of the atmosphere.

Baron Boyer, in his "Treatise on Surgical Diseases," employs gangrene as synonymous with sphacelus, or complete death of the part, and local asphyxia for that condition in which the parts are in a state of suspended animation, and are consequently susceptible of resuscitation; thus: —

"Gangrene is the death of a part of the body; that is, the perfect abolition of its sense, motion, and organic action. This last condition is essential to a definition of gangrene; for all sense and motion of a part may be destroyed, and yet its life preserved, as we see in paralysis, a disease in which the organic motion of the vessels is not destroyed.

Baron Boyer employs gangrene as synonymous with sphacelus, and applies the term local asphyxia to that condition in which the parts are in a state of suspended animation.

"Gangrene ought not to be confounded with local asphyxia, or the state of apparent death of a part; for, in the last disease, the life only being suspended, may be again restored. Thus gangrene is to local asphyxia what death is to general asphyxia. There are some examples of local asphyxia in which the heat, sensibility, and motion, the pulsation of the arteries, in fine, all the phenomena of life, after having appeared annihilated for some days, are gradually reanimated, and resume all their vigor.

"De La Mothe relates the case of a billiard-table boy, whose right hand was so asphyxied by a blow of a stick on the external part of the arm, that it appeared dead for ten days; but at the end of this time the heat returned gradually, the pulsation of the arteries was perceived, and the hand restored to its natural state.

"When the principal artery of a limb is tied, it has been believed by some that it was deprived of life, because below the ligation it showed neither sensation, motion, nor pulsation of the arteries. However, it often happens that, after having remained in this state some time, it revives by degrees.

"It is important to distinguish this state of local asphyxia from gangrene, because otherwise we should be inclined to amputate a limb capable of being restored to life, or perform operations which would be followed by results more or less injurious. We shall avoid this serious mistake, if we observe that in the case of a limb apparently deprived of life, the article is not detached, as in gangrene; and we do not find that putrid dissolution nor the fetid odor which is peculiar to this disease.

"Nevertheless, putrid dissolution and gangrene are not to be regarded as identical. In fact, mortification always precedes the putrid dissolution, or that kind of fermentation which destroys the organic structure of a part affected with gangrene, and disengages several of its elements in the form of gases of a fetid odor.

"It is true that in many instances of gangrene, the affected part is so speedily separated by sloughing, that the symptoms of putrefaction appear almost as soon as those of mortification; but we ought not the less to distinguish these two states, which have been confounded by several authors. We observe them well marked and regular in succession; in the gangrene which results from tying the principal artery of a limb, and that produced by cold; for in these two cases we evidently see that life is extinct in the part, some time before the development of the phenomena of putrefaction.

"When gangrene is confined to the common integuments, and to the subcutaneous cellular tissue, it receives the name of gangrene simply. It takes the name of sphacelus, when it affects the flesh, the vessels, and the bones themselves; and in a word, when a limb is mortified throughout its whole thickness. But gangrene and mortification are, in fact, but two degrees of the same affection, and the distinctions which several authors have made between them, are not founded on good grounds. In fact, gangrene is the absolute death of the part which it affects. If the life of a part be not entirely destroyed, it may be recalled, and no gangrene exist. Thus the name of gangrene, which has been given to that state of the parts in which the weakness of the vital powers only threatens mortification, is evidently misapplied.

"When the cause of gangrene drives to the part affected a large quantity of fluids, swelling precedes mortification, and the humors confined there soon run into putrefaction. The gangrene is then called humid.

"If, on the contrary, the cause of the disease hinders the approach of the fluids from the beginning, if it affect a part which contains only its natural quantity of them, as the cause then acts by coagulating the liquids and the solids, the member diminishes in size, the flesh shrinks like tanned leather, and is harder to cut than a living part. In this case the gangrene takes the name of dry gangrene."[1]

Baron Boyer separated the varieties of gangrene into two grand divisions: —

I. Gangrene from external causes.

The external causes which may produce gangrene were referred by this author to inflammation, contusion, slow compression,

[1] *A Treatise on Surgical Diseases and the Operations suited to them*, by Baron Boyer, Member of the Legion of Honor, etc. Translated by A. H. Stevens, M. D. New York, 1815. Vol. i. pp. 57, 58.

burning, congelation, and the interception of the course of the fluids.

II. Gangrene from internal causes.

First, gangrene produced by the malignity of the cause of inflammation; second, that which supervenes in the course of a malignant or putrid fever; third, that which has received the appellation of dry gangrene.

Baron Larrey divided gangrene into spontaneous and traumatic, and endeavored to found rules for amputation upon this distinction.

Baron Larrey, in his "Memoir on Traumatic Gangrene, or Gangrene produced by Wounds," published in his "Memoirs of Military Surgery," divided gangrene into spontaneous and traumatic, and endeavored to found rules for amputation upon the distinctions which he drew between these varieties of mortification.

Under the former, he included dry gangrene, produced by an internal cause, or by the abstraction of heat from a part, as in congelation or gangrene from frost.

Under the latter he included moist gangrene, arising from mechanical injuries and hospital gangrene.

Spontaneous gangrene of Larrey.

According to Larrey, in spontaneous gangrene, the part affected turns black, and instead of puffing up as in traumatic gangrene, shrinks, dies, and sometimes hardens like horn: a well-defined inflammatory line appears, separates the sound from the gangrenous parts, and prevents the propagation of the gangrenous principle towards the centre of life, in consequence of the obstruction produced by inflammation in the mouths of the vessels in the cellular substance, and in the lymphatic system. In this form of gangrene, therefore, he affirms that no inconvenience can ensue if we choose to wait when amputation is indicated, until the mortification be defined.

Traumatic or moist gangrene of Larrey.

Traumatic or moist gangrene, on the other hand, arising from external and mechanical causes which directly injure the vitality of the parts, is always preceded by an inflammatory obstruction, erethismus, and rupture of more or less of the capillary system. The parts are tumefied by their vital action, which is not yet extinct; the epidermis is separated, and forms phlyctæna, filled with a serum that should have been discharged by transpiration; the cutis grows soft, becomes black, and putrefies; the cellular substance is decomposed, with all the membranes; a redundant quantity of fluid, which has escaped from the vessels and adipose substance, is found in the parts, and hence the name, moist gangrene.

Yet in the centre of this sphacelus, more especially when the

destruction of the limb is not complete, or the injury has not been uncommonly violent, may be found muscles, arteries, and nerves possessed of life. Such also is the fact in the hospital sore, or sphacelus, which decomposes and melts down all the adipose substance, while the muscular fibre and the arterial tubes remain of a red color in the midst of dissolution.

Spontaneous gangrene generally appears in those parts farthest removed from the heart, or in such as are debilitated or have their vital power diminished, as the feet, the nose, the ears, and the fingers; and the absorption of the gangrenous matter is effected with difficulty, the disease remains latent for an indefinite time, and it is not unusual to see the sphacelus or necrosis separated from the living parts by the power of nature alone, without a change in the general functions; while on the other hand, traumatic gangrene can take place in any wounded part, and may propagate itself rapidly and in succession through the parts from one limb to another, seize on the trunk, infect the organs of life, and destroy the patient. In addition to the local and gradually extending inflammation, a metastasis of the gangrenous principles to the brain is induced either through the cellular substance or vascular system, and the most alarming symptoms ensue. The intellectual faculties are disturbed, and the animal functions impaired, paleness of the face, anxiety, delirium, and all the symptoms of ataxia make their appearance, and if this infection continues the patient must soon expire.

From this view of the subject, Baron Larrey concludes, not merely that there is an essential difference between the traumatic or moist gangrene, from external causes, and the spontaneous or dry gangrene, from internal causes, but also that in the first species of gangrene it would be dangerous to wait until it had become defined by the reddish circle or line, because putrefaction advances without any opposition, not only by contagion, but by absorption or transmission from the part first affected; there should, therefore, be no hesitation to perform immediate amputation, when once the necessity of it is well established.

Larrey still further affirms that we need not fear that gangrene will attack the stump, as in spontaneous mortification which is not defined; for traumatic gangrene, after being produced by a local cause, is propagated or extended by absorption. Amputation, therefore, first removes the contagious matter when performed above the parts in a state of real gangrene; the nerves and vessels are set at liberty when divided by a sharp instrument, and they

are thus relieved from fluids that are in a state of stagnation, their action is reëstablished; and far from performing the part of syphons by absorbing heterogeneous principles, they are enabled to expel these principles, and the fluids they contain, and subsequently to relieve the principle of life.

Criticism of Guthrie on the division of gangrene by Baron Larrey.

Guthrie, in his "Treatise on Gunshot Wounds," has criticised the division of gangrene by Baron Larrey, and the practical deductions from the character and relations of the two species, on the ground that neither the state of constitution, nor of parts, nor the surgical treatment, are at all times alike, and because they may even differ most essentially in a very short space of time.

Mr. Guthrie makes an additional distinction of constitutional and local gangrene, including the humid and the dry, under either as it might happen that the constitution was or was not involved.

Mr. Guthrie makes an additional distinction of constitutional and local gangrene, including the humid and the dry under either, as it might happen that the constitution was or was not materially affected. According to this author, the terms constitutional humid and dry gangrene do not mean only gangrene which has originated idiopathically, but that in which the constitution or system at large is, or has been affected primarily or secondarily. By local humid and dry gangrene, on the other hand, should be understood a state of disease of a particular part, by which the constitution or system at large has not been implicated, or only sympathizes in a degree which is not felt to be generally detrimental to its powers of originating and maintaining action, which may be subsequently required for the safety of the whole.

Mr. Guthrie affirms that traumatic gangrene may, in opposition to the opinion of Baron Larrey, be of two kinds, humid and dry, or both species may obtain in a limb at the same time, but under particular circumstances.[1]

It is evident, therefore, that if both varieties of gangrene can arise from the same cause, exist at the same time in the same person and even in the same limbs, the terms humid and dry gangrene, however comprehensive and apparently useful, are nevertheless based upon arbitrary distinctions, and must be abandoned as generic terms in a perfect system of classification.

Term gangrenous inflammation employed by Travers.

The term mortification has been objected to, on the ground that it is not technically explicit, and has been vaguely and indiscriminately used; and the term gangrenous inflammation has been employed by Mr. Travers as indicating

[1] *A Treatise on Gunshot Wounds, on Inflammation, Erysipelas, and Mortification, on Injuries of Nerves*, etc., by G. J. Guthrie, F. R. S., etc. 3d edition, London, 1827, pp. 115, 116, 125.

the stages of recoverable and irrecoverable, threatened and devitalized texture. This author substitutes gangrene for sphacelus, and designates by the former substantive term a state of utter death, in which the part becomes subject to chemical changes, as if severed from the body.

Chelius, in his "System of Surgery," defines mortification to be the passage of inflammation into partial death, and the subjection of the mortified part to the general chemical laws. Under the name mortification, Chelius distinguishes two conditions, namely, the hot mortification, in which the living power is not perfectly extinguished, and in which it may be restored to its natural action; and the cold mortification, in which the part is actually dead.

Definition of mortification by Chelius.

The hot mortification of Chelius corresponds therefore with the gangrene of Thomson and many other writers, and with the gangrenous inflammation of Travers; and the cold mortification of Chelius is synonymous with the sphacelus of Galen and others, and with the gangrene of Travers.

Two of the most recent and able English authorities upon this subject, although employing pretty much the same divisions and method, have used the words mortification and gangrene each in a different manner. Thus Dr. R. Carswell employs the term mortification in the generic sense as it has been most generally employed by English writers, constituting a generic sign of the disease of which gangrene and sphacelus indicate particular stages.

Dr. Carswell employs the term mortification in a generic sense.

Dr. James Copland, on the other hand, employs the word gangrene in a generic sense, as has been customary with continental writers, and applies the term mortification to the last result or termination of the morbid state.

Dr. Copland employs the word gangrene in a generic sense.

This examination of the modes in which this subject has been treated, and of the different ways in which important terms have been employed, might be greatly extended, but it is believed that these examples will not only illustrate the necessity for a more accurate classification of the varieties of gangrene than that now employed in the Confederate "Sick and Wounded Reports," but will also constitute an excuse for the attempt on our part to indicate the method which we believe to be the best for the investigation and classification of this subject.

In the following observations upon the method of investigation and classification of the phenomena of mortification, this term will be used as a generic sign of the disease of which gangrene and

sphacelus indicate particular stages, after the manner of Thomson and other English physicians.

OBSERVATIONS UPON THE METHOD OF INVESTIGATION AND CLASSIFICATION OF THE PHENOMENA OF MORTIFICATION.

Method of investigation and classification of the phenomena of mortification.

The classification of the varieties of mortification should be based upon the knowledge of the causes producing the degeneration and death of the tissues or organs, and of the nature and relations of the physical, chemical, and nutritive changes of the affected tissues in health and during the different stages of disease and mortification; and upon the knowledge of the effects of the changes and their organic products upon the surrounding tissues, and upon the vegetable and animal functions.

The correct comprehension of the complicated phenomena of any case of gangrene includes a knowledge of—

1. The physical and chemical constitution and physiological functions of the tissue, structure, or organ involved; the physical and chemical constitution and relations of the blood circulating through the affected part; and the relations of the tissue, structure, or organ to the respiration and circulation, and to the cerebro-spinal and sympathetic nervous system.

2. The condition of the general system at the time of the appearance of the symptoms of mortification.

Certain modes of life and certain articles of food induce a state of the system favorable to the origin of gangrenous inflammation.

It is well established that certain modes of life and certain substances taken as food, induce such a state of the system as is favorable to the origin of gangrenous inflammation upon the reception of trivial injuries, or they may even induce mortification without any local injury. In such cases we need something more than a mere description of symptoms and of the progressive appearances of the gangrenous parts; and we cannot claim a thorough knowledge of this phenomenon until we understand the changes of nutrition during the progres sive degeneration of parts. This subject is involved in numerous and great if not insurmountable difficulties. In most cases of gangrene it is difficult if not impossible to determine the point at which the tissues commence to degenerate; and even after it has been well established that the nutritive and vital functions are defective, it is almost impossible to distinguish between degeneration and death. Thus a part may degenerate to death, whilst the surrounding tissues, although greatly degenerated and altered, may still present signs of life, and neither be cast off or absorbed; so also while a

certain diminution of arterial blood may lead only to deranged nutrition and degeneration, a greater diminution may lead to death; and a certain degree of inflammatory action has always a defective nutrition and consequent degeneration, whilst in an increase of the inflammation the death of the same part may ensue.

3. The nature of the cause producing gangrene; if mechanical, the nature and extent of the injury; if chemical, the properties of the substance, and its actions upon and chemical and physical relations with the living tissues; if a mineral, vegetable, or animal poison, its chemical affinities and relations, not merely to the tissues or organs involved, but to the circulatory, respiratory, and nervous systems, and to the vegetable and animal functions.

4. The chemical constitution of the various products formed at the different stages of the mortification, and the effects of these organic compounds upon the constitution of the blood, upon the nutrition of the surrounding tissues and of the system generally, and upon the actions of the circulatory, respiratory, and nervous systems.

Different organic compounds formed during the putrefaction of animal matters subjected to different conditions and agents.

The organic compounds formed during the putrefaction of animal matters removed from the living body, must, without doubt, differ in chemical constitution and physiological action from those formed during mortification in the living body. Putrefaction under these different conditions must necessarily yield different products from the differences of temperature, and the presence of surrounding organized living tissues and fluids in the one case, and their absence in the other. In like manner the products formed will vary with the different varieties of mortification. When inflamed parts, with a large amount of exudation, pass into mortification from a loss of vitality or from the obstruction of the circulation caused by the exudation, or from both causes combined, the products formed during the death and decay of the moist distended tissues will differ from those formed when the parts undergo little or no inflammation, and simply die, shrivel up, and become black, as in senile gangrene. The rapidity of the putrefaction of organic substances is in general in proportion to the degree of temperature, and the supplies of oxygen and water. The character of the compound formed will vary with the manner in which these essential conditions are fulfilled. If the supply of oxygen be deficient, an excess of carbon and carbonaceous compounds will be found in the dead mass, which otherwise would have been transformed and

removed chiefly in the form of carbonic acid gas. Some of these compounds, formed under peculiar circumstances both without and within the living body, are capable of acting the part of ferments and of exciting decomposition in neighboring masses. We can in this manner find an explanation of the rapid and progressive destruction of the surrounding tissues in hospital gangrene, cancrum, oris, noma, and some other malignant forms of mortification.

The extent to which the general system will be infected by the products of gangrene, will depend in a great measure upon the condition of the constitution, and surrounding tissues.

The extent to which the general system will suffer from the infection of the dead matters and poisonous compounds, will depend in great measure upon the condition of the constitution, and surrounding tissues. When the constitution is robust, and the vascular system well developed and active, with rich, healthy blood, active inflammation is excited around the dead part, and an effusion of coagulable lymph surrounds and limits the local disease, and tends to protect the general system from infection. In those cases in which the mortification is thus circumscribed, the predominant symptoms will be those of inflammation and inflammatory fever; but if the constitution be primarily enfeebled, and the blood be defective in its constitution and vital properties, or if the forces be secondarily depressed, and the nutrition impaired, and the blood deteriorated during the progress of the inflammatory fever, the general system will suffer from the absorption of the poisonous compounds. The absorption of the poisonous animal matters will be announced by the increased feebleness and frequency of the pulse, the pallidity and duskiness of the complexion, the distressed, anxious countenance, with collapsed, pinched features, cold sweats, the dry or clammy, brown-coated tongue, restlessness and agitation, low muttering delirium, hiccough, fetid diarrhœa, coma or syncope, and death. The rapidity with which the products of mortification will be absorbed and affect the system, depends not only upon the condition of the blood and forces, and of the general constitution, but also upon the organ or tissue involved, the absorption being, as a general rule, most rapid and deleterious in its effects when the dead part is in the interior of the body in some vital organ, and surrounded by an extensive vascular net-work.

5. The relations of the different stages of mortification to the different stages of other diseased actions, as the stages of inflammation and fever.

6. The processes by which nature limits or arrests the destructive progress of mortification.

It is evident that the thorough investigation of the relations of mortification here pointed out, would not only necessitate immense labor, but also the discovery and invention of methods of experiment, and of tests and apparatus unknown to pathological science.

The varieties of mortification may be arranged under the following heads: —

I. — MORTIFICATION ARISING FROM MECHANICAL INJURIES, AND THE LOCAL ACTION OF PHYSICAL AND CHEMICAL AGENTS.

Mortification arising from mechanical injuries, and the local action of physical and chemical agents.

As severe mechanical injury, great heat, or powerful chemical agents may kill the structures and contained blood at once, without any preceding inflammation, we are justified in classing this as the most simple and uncomplicated form of mortification.

When, however, these agents are applied in smaller measure, they may fail to cause mortification directly, but may excite an inflammation which, added to the damage that the part has sustained, may result in an indirect or secondary mortification.

This first division may be subdivided into mortifications resulting from —

(*a.*) Mechanical injury of blood-vessels.
(*b.*) Mechanical injury of nerves.
(*c.*) Mechanical injury of the entire structure.
(*d.*) Effects of heat.
(*e.*) Effects of cold.
(*f.*) Effects of destructive corrosive chemical agents, as the mineral acids, etc.

The extent and character of the mortification arising from mechanical injuries, and the local action of physical and chemical agents, will depend not merely upon the nature of the injury, but in a large degree upon the condition of the constitution.

The extent and character of the mortification arising from mechanical injuries, and the local action of physical and chemical agents, will depend, not merely upon the nature of the injury, but in a large degree upon the condition of the constitution.

Thus slight injuries, not sufficient to excite gangrenous inflammation in healthy persons, will be attended with extensive and even fatal mortification in habitual drunkards, and in the enfeebled, depressed state of the system often found in old age, and after long continued fevers. The rapid destruction of tissue in parts exposed to pressure (bed-sores) following fevers of a low type, appears to be due to the depressed state of the forces, and to imperfect nutrition, as well as to the action of morbific agents.

An excess or deficiency of blood, as well as variations in the constitution and relative proportions of the constituents of this fluid, will influence the extent and character of the inflammation and mortification following local injuries.

Although mortification arising from the action of mechanical and physical causes may at first appear to be strictly local, at the same time the constitution, even in the most simple and favorable cases, is more or less involved. Thus, if the life of a large portion of the tissues in the middle of the leg be destroyed by a cannon-ball, which fractures the bone, divides the arteries, or renders them incapable of carrying on a sufficient circulation for the nutrition of the tissues which they supply, mortification may take place in the injured tissues or in the foot imperfectly supplied with blood, immediately; or there may be first an inflammatory action established in the parts above and around the injured tissues, and at the same time an imperfect manifestation of the phenomena of inflammation in the foot. As soon as inflammation is established in any part, either in the parts in and around the wound, or in the foot imperfectly supplied with blood, the action of the circulation and respiration is increased, the chemical changes become more active, the temperature of the entire body is elevated, the appetite fails, the urine becomes high-colored, the nervous system manifests signs of sympathetic derangement, and the constitution is involved.

After the parts pass into the gangrenous state, various abnormal organic products result from their decomposition, which, entering into the circulation, disorganize the blood, derange the nutrition of the surrounding parts and of the body generally, depress and derange the actions of the circulatory and nervous systems, and still further aggravate the constitutional systems.

II. — MORTIFICATION ARISING FROM AND FOLLOWING INFLAMMATIONS OF IMPORTANT ORGANS AND STRUCTURES, WITHOUT ANY EXTERNAL INJURY.

Mortification arising from and following inflammation of important organs and structures, without any external injury; the extent and character of this variety of mortifica-

The extent and character of this variety of mortification, will manifestly depend in great measure upon the function of the organs or structures inflamed, as well as upon the causes, character, and extent of the inflammation.

The causes of the irritation and inflammation of internal organs are various, as changes of temperature; derangements of the circulation; derangements of the nutrition, resulting from bad diet, impaired digestion, improper habits, exposure, the depressing effects of moisture, heat

and cold, and from derangements of the physical and chemical properties of the blood; nervous derangements; imperfect elimination of excretory substances, as uric acid, and other noxious compounds resulting from the imperfect action of the skin and kidneys; and the action of various morbific agents introduced from without or generated within the system, upon the organs directly, or through the blood and nervous system.

tion will depend upon the function of the organs or structures inflamed, as well as upon the causes, character, and extent of the inflammation.

In inflammations, when a very large amount of blood plasma is thrown out, the capillaries are ruptured, the blood with its red corpuscles is mixed with the exuded liquor sanguinis, and the exudation thus formed compresses the parts, paralyzes the nerves, obstructs the blood-vessels, and arrests the circulation; whether such products of inflammation, with the injured tissues, will pass into mortification, will depend upon the extent to which the powers of the general system have been prostrated, and upon the extent to which the circulation and nutrition of the parts have been deranged. If the vital powers are too much depressed to organize the exudation into living cells, or are incapable of the slow removal of the products of inflammation by absorption, the physical and chemical forces are no longer directed by the vital force to the constant destruction and repair of the structure, and a new set of chemical changes are set up, resulting in mortification; the constituents of the blood are altered in their physical and chemical properties; the blood corpuscles assume a dark purple and black color, and finally break down and disintegrate; the tissues of the part enter into the general change; the fibrous cellular and muscular tissues are detached, and finally decomposed into amorphous granular masses; and various deleterious and offensive gases, as sulphureted hydrogen and compounds of ammonia, with many organic compounds, are formed. Whilst in this manner inflammation may terminate in gangrene, we should not regard the various results of inflammation, as adhesion, exudation, suppuration, and absorption, as connected with mortification, or as forming necessary steps leading to gangrene. We may have mortification without any of the intermediate stages of inflammation, as we hope to be able to show in the case of the action of certain animal poisons, as the poison of the rattlesnake, which produces almost instant death of the blood and tissues into which it is injected. Nevertheless, we cannot understand mortification following inflammation, without considering the preceding process, with its various products; for inflammation, however produced, may cause morti-

fication from the complete suspension of the circulation of the part, resulting from the congestion and stagnation of the blood, or from the pressure of the inflammatory products, or from inflammation of the internal coats of an artery; from the derangement and depression of the powers of the general system, as well as of the part especially involved, by the exhausting effects of the preceding inflammatory fever; and from the degeneration of the blood and tissues dependent upon the defective nutrition consequent upon the inflammatory actions. The death of an inflamed part, therefore, is a highly complex matter.

III. — MORTIFICATION ARISING FROM CONSTITUTIONAL DERANGEMENTS AND ALTERATIONS IN THE CIRCULATORY APPARATUS, WITHOUT ANY LOCAL INJURY OR INTERNAL INFLAMMATION.

Under this head may be classed mortification arising from —

(*a.*) Derangements in the quantity, composition, and circulation of the blood; as in scurvy.

(*b.*) Deficient and perverted nutrition.

As in the mortification of the feet and toes described by Percival Pott, which he affirmed to be unlike the mortification from inflammation, from external cold, from ligature or bandage, or from that which proceeds from any known and visible cause.

(*c.*) Decay of the powers, feeble action of the heart, and structural alterations of the circulatory apparatus, resulting from deficient and perverted nutrition; as in senile gangrene.

(*d.*) Deficient and perverted nutrition, and feeble forces, and altered blood, resulting from the prolonged action of disease, and especially of fever.

IV. — MORTIFICATION ARISING FROM THE ACTION OF SPECIAL POISONS EITHER DEVELOPED WITHIN THE SYSTEM, OR INTRODUCED FROM WITHOUT THROUGH THE ALIMENTARY CANAL, RESPIRATORY SYSTEM OR SKIN; OR THROUGH THE BLOOD; OR THROUGH WOUNDS AND ULCERS.

Under this head may be classed mortifications arising from —

(*a.*) The action of various mineral bodies; as arsenic and mercury.

(*b.*) Vegetable poisons.

As in the gangrene produced by spurred rye (gangrenous ergotism; necrosis ustalagenia; Sauvages; gangrene des solognois).

(*c.*) Poisonous animal secretions.

As the poison of the rattlesnake (*Crotalus adamenteus et durissus*), and of the copperhead (*Trigonocephalus contortrix*), and of the European viper, and other reptiles.

(*d.*) Fever poisons.

As in certain forms of typhus fever.

(*e.*) Deleterious agents generated in animals in a state of disease.

As in malignant pustule (Pustule maligne, charbon, Milzbrand).

(*f.*) Poisonous compounds generated during the decomposition of dead animal matters.

As in dissecting wounds.

(*g.*) Poisonous decomposing animal matters, formed in the gangrenous wounds of living men, capable of infecting the system either through the lungs or through the surface of wounds and ulcers.

To the last variety belongs hospital gangrene (phagedæna gangrænosa).

The previous condition of the constitution will be especially influential upon the course and results of gangrene arising from the action of the products of animal decay. This might be supported by numerous facts, as the comparative immunity of American medical students from poisoning in dissecting wounds in the early part of the course of lectures, when their systems are in vigorous health; and the more frequent occurrence of poisoned wounds in the latter portion of the course, after their forces have been exhausted, digestion impaired, and blood impoverished by want of exercise, excessive application, poor diet, and the foul atmosphere of the dissecting room, and of the crowded and badly ventilated lecture rooms.

We will also endeavor to demonstrate, in the course of this work, the effects of previous exposure, bad diet, crowding, and foul air, upon the origin and spread of hospital gangrene amongst the Confederate soldiers and Federal prisoners.

Before entering upon the results of our labors upon hospital gangrene, it may prove both interesting and profitable, for purposes of comparison, that some notes should be recorded upon the early history of this disease. Cut off entirely from surrounding nations, and with the enemy ravaging my native State from the mountains to the seaboard, it will be in my power to do nothing more than to present the facts afforded by my private library, and by the library of the Medical College of Georgia.

NOTES UPON THE HISTORY OF HOSPITAL GANGRENE.

It is impossible to determine the time of the first appearance of hospital gangrene.

History of hospital gangrene. Impossible to determine the time of the first appearance of the disease.

The records of the ancients furnish only negative testimony; that is, we are not justified in asserting that this disease had never appeared amongst the wounded of the immense armies of the ancients, simply because a description is not preserved in the fragments of their writings which have come down to us. Not only have many of the works of the ancients been lost, but it would also appear that amongst some of the greatest nations of antiquity, it was impossible that any accurate history of diseases could have been written, because of the absence of both medical science, and of physicians devoted to the treatment of disease. Thus, Herodotus affirms that the Assyrians, even at the time of the greatest splendor and power of the Babylonian empire, had no physicians, but were in the habit of exposing the sick in the market-place, that they might confer about their diseases with the passing multitude. If the passers by had themselves been afflicted with the same disease as the sick person, or had seen others so afflicted, they advised him to have recourse to the same treatment as that by which they escaped a similar disease, or as they had known to cure others. Herodotus also relates, that amongst that nation of the Indians called Padæans, who were cannibals, it was the custom when any one of the community was taken sick, whether man or woman, for the nearest connections to put the sick person to death; and they justified this barbarous treatment on the ground that if the sick person wasted with disease, his flesh would be spoiled. Those attaining old age were in like manner sacrificed and devoured. Herodotus adds that but few amongst them attained to the state of old age, for before the limit of life was reached, every one had been destroyed for some distemper.

According to Herodotus, the Assyrians had no physicians. Exposure of the sick in the market-place.

Whilst it is true that the first body of doctrine in the history of medicine is the collection of writings known under the name of the works of Hippocrates, it is also true that the science of medicine mounts up directly to this source, on account of the loss of the records of the earliest cultivators. In like manner, there exists a great gap after the writings of Hippocrates, the works from his time to the establishment of the school of Alexandria, and those of that school itself, having been completely lost, with the exception

of some quotations and passages preserved in the latter writers. It appears, farther, that the Greeks received surgery, together with the other branches of medicine, from the Egyptians; and from some observations made by the learned men of the French expedition to Egypt in 1798, it is evident that in very remote times, this extraordinary people had made a great degree of progress in the art of surgery. Upon the ceilings and walls of the temples of Tentyra, Karnack, Luxor, etc., basso-relievos are seen, representing limbs that have been cut off with instruments very analogous to those which are employed at the present day for amputations. The same instruments are said to be again observed in the hieroglyphics, and vestiges of other surgical operations may be traced, which afford convincing proofs of the skill of the ancient physicians in this branch of medical science.

The Greeks received surgery, together with the other branches of medicine, from the Egyptians.

Whilst it may be true that in the early ages of the world there could not be much occasion for medical science, on account of the simplicity of manners, and plainness of diet, and temperance in meat and drink, and the active pastoral life of the first inhabitants, and that as the world became more populous, and the people were gathered together in crowded cities, various epidemic and contagious diseases appeared, which were before unknown; at the same time it is in like manner true that the texture and materials of construction and scarcity of the clothing of the ancients tended to the generation and propagation of various contagious diseases, and especially of skin diseases.

The construction and scarcity of the clothing of the ancients tended to the generation and propagation of various contagious diseases.

Reasoning from our present knowledge of the mode of origin and propagation of hospital gangrene, we are led to infer that in equal numbers of wounded in ancient and modern times, the more vigorous constitutions and more simple habits of the former, as well as the custom of sleeping in the open air without tents or houses, would greatly tend to prevent the occurrence of such diseases as erysipelas and hospital gangrene; while on the other hand, the scanty supply of suitable materials for dressing and cleansing the wounds, would tend to promote the origin of these diseases, even when the wounded were kept in the open air.

As far as our knowledge of the immense armies of the ancients extends, we are led to believe that they were subject to very much the same forms of fever, bowel affections, and pestilence, generated by the collection of large masses of human beings, which afflict modern armies. Thus, we

The immense armies of the ancients subject to very much the same forms of

fever and bowel affections which afflict modern armies.

find allusions to the pestilence amongst armies and in beleaguered cities, in the sacred writings of the Hebrews; and Homer opens the "Iliad" with an account of a fatal pestilence in the camp of the Achæans, which sent many gallant souls of heroes to Hades, and made their carcasses a prey to dogs and birds of prey. Herodotus relates that during the hasty retreat of Xerxes from Mardonius, in Thessaly, to the Hellespont, a large portion of his army perished from hunger, dysentery, and pestilence.

According to Pliny, the army of Cæsar suffered with scurvy.

Pliny, in his "Natural History," refers to a disease called by medical men *stomacace* and *sceloturbe*, characterized by loss of the teeth and total relaxation of the joints of the knees, which afflicted the army of Cæsar, in his German campaign, and which, from its cause, symptoms, and method of cure, appears to have been the scurvy. This disease appeared in a Roman camp beyond the river Rhenus, near the sea. The water was brackish, and the only fresh water to be obtained was from a spring in the vicinity of the sea. The habitual use of this water for two years, caused the loss of the teeth, and general debility. A remedy was discovered in the plant known as the *britannica*, which Sprengel and Desfontaines identify with the *Rumex aquaticus*, and Lee with the *Inula britannica* of Linnæus. It is probable that the Romans were not unacquainted with scurvy, and with the best means of preventing this disease; for they are said to have constantly carried vinegar and wine in their fleets and armies, and even the common soldier and sailor daily partook of both. These facts are of interest, for in modern fleets and armies scurvy has often been associated with the most dangerous forms of hospital gangrene. We might multiply these examples by reference to the pestilential fevers which afflicted the Grecian and Roman armies at various times, but we will reserve the consideration of such facts to the examination of the origin of typhus and typhoid fevers.

The silence of many of the ancient writers with reference to the origin and spread of contagious diseases in armies and crowded cities, may be due to several causes. Thus, it has been said that amongst the ancients the dread of poison was the continual alloy of successful ambition, and the object of medicine was rather to discover antidotes, than to record the symptoms of disease and discover remedies. Many of the older writers, as has been remarked by Fracastorius and some others, were thought to have been unacquainted with contagious diseases, or rather with the mode of

origin and communication of those infectious disorders which arise from a mere tainted atmosphere, in consequence of the too close accumulation of diseased subjects; and yet there are observations which render it probable that the danger of the intercourse with the sick in certain diseases was so well known to the historians of the classical age, that the physicians thought it unnecessary to dwell upon an established and widely admitted fact. Mr. Adams, in his work on "Morbid Poisons," has well remarked, that contagious diseases were less attended to than in the present day, because of the greater separation of the different classes of mankind, and the prevalence of contagious diseases chiefly amongst the poorest classes.

"The different classes of mankind were more separated, and the destruction of thousands of slaves, or the plebeian race, was a matter little felt by the higher ranks. In the plague described by Homer, it does not appear that any of the chiefs suffered; but the lessened number in the ranks at last became an object of consequence, and the hero who first thought this calamity worth notice, is throughout the poem described as particularly attentive to his myrmidons. In the siege of Syracuse, the Carthaginian generals, having no advantage above the privates, all perished; but considerable as the mortality was among the Romans, all the generals escaped. For the most part in war, and still more in peaceable times, famine was the forerunner of pestilence, and the rich generally escaped both. The disease ceased with the cause which produced it, and the individuals who fell were scarcely known, except by their nearest connections. . . . . In military expeditions, it was of more consequence; and it is worthy of remarking that in proportion as a nation became more martial, all the means of avoiding the causes of such diseases became a part of their discipline. Who can possibly forget the lively description of a Hebrew camp (Num. xxiv. 5), given by an enemy during the military period of that once warlike nation, or of Leonidas' troops, when waiting the assault from the largest army the world had ever seen — some exercising themselves and others combing their hair. Among the Roman historians, 'corpus curari' is an expression which perpetually occurs in describing the progress of armies. Add to this, their clothing was more simple, and the want of linen rendered frequent bathing an indispensable custom. When the severity of the service obliged them to dispense with these habits, we have seen that they suffered like modern armies."

The strongest argument against the ancient existence of hospital gangrene lies in the fact which is well established by the writings of the Hebrews, of Homer, Herodotus, Cæsar, Plutarch, and others, that notwithstanding the immense

The strongest argument against the ancient existence of

hospital gangrene lies in the fact that comparatively few wounded survived ancient battles.

armies of the ancients, and the immense slaughter which took place in their battles, the dead being numbered by tens and even hundreds of thousands, at the same time there were few or no wounded who survived the immediate conflict. The contending armies of the ancients came to close quarters, and engaged in desperate hand-to-hand fights. In such contests it was difficult, if not impossible, to remove the wounded from the field of battle; and as soon as an adversary had wounded or disabled his antagonist, he followed up his advantage, and did not desist until his victim was slain and robbed of his armor. The qualifications of the ancient warrior were very different from those considered essential in modern times. The rigid discipline and mechanical movements of modern armies were unknown in ancient times, and the success of the warrior depended chiefly upon his strength and presence of mind, personal bravery, experience in the use of weapons, bodily strength, and agility. The eye of the ancient warrior acquired an animation, his countenance an expression of fierceness and eagerness, and his voice a power and variety of cadence, and his whole frame a degree of athletic force and energy unknown amongst the comparatively sluggish and mechanical masses of modern armies.

Description of ancient battles by Homer.

Thus, Homer describes the Trojans as advancing to battle with a clamor and a shout, like the scream of cranes when flying from winter and excessive rains they wing their way over the floods of Oceanus, carrying death and destruction to the pygmies, while the Grecians moved on in silence, breathing forth valor; and, as the south wind spreads a mist upon the brow of a mountain, by no means agreeable to the shepherd, but to the robber better than night, in which a man sees as far only as he can cast a stone, so rose the troubled dust under the feet of the hostile hosts as they rushed across the plain. When Alexander advanced in front of the Trojans with the skin of a panther on his shoulders, and shaking two brazen pointed spears, challenged the chief of the Grecians to meet him in mortal combat, Menelaus, perceiving his adversary advancing with long strides, rejoiced like a hungry lion who lights upon a huge carcass, and, burning with revenge, leaped from his car to the ground. Again, in the second meeting of the hostile armies, Homer compares the advance of the columns of the Grecians to the rushing of waves upon a resounding shore, which, rising in the deep water and urged on by the winds, are dashed against the land, roaring and swelling and curling around the rocks. When advancing on both

sides the armies meet, the spears, and bossed shields, and brazen corselets are dashed together, the earth flows with blood, and the shriek and shout of the slaughtering and slaughtered warriors mingle together, as when the torrents of winter, rolling down the steep mountain from their vast sources, pour together their foaming waters into some lake within the hollow glen.

The description by Homer of the personal conflicts of the individual warriors, still more forcibly illustrates the deadly and ferocious nature of ancient battles, and explains the reason of the disparity between the wounded and the slain. The Grecian Antilochus was the first who slew a Trojan warrior; his brazen spear struck the cone of the helmet crested with horse-hair, of Echepolus, and pierced the helmet and bone within. Elephēnor, the leader of the Abantes, seized Echepolus by the feet as he fell, and dragged him from amongst the weapons, that he might plunder him of his armor; but his eager efforts were short, for Agēnor, seeing him dragging the body, thrust his brazen spear into his side, which was uncovered by his shield as he stooped. Over the dead body of Elephēnor, the Trojans and Grecians rushed upon each other like wolves, and engaged in deadly strife. Here the Telamonian Ajax, with his spear, struck upon the breast, near the right pap, Simœisius, a noble and vigorous youth, and the brazen spear went to the opposite side, through the shoulder. Antipus, a son of Priam, then hurled his sharp javelin at Ajax, and, missing him, wounded Leucus, the brave comrade of Ulysses, as he was dragging the body of the youthful warrior to the other side, and the body dropped from his hands, and he fell upon it. Then Ulysses, enraged on account of the slain, armed in glittering brass, advanced amongst the foremost combatants, and, looking around, threw his shining spear, which struck Democoön, a bastard son of Priam, upon the temple, and his armor rang upon him as he fell with a crash. Hector and the foremost warriors then giving way, the Argives loudly shouted, dragged away the dead bodies for plunder, and rushed forward. After the Trojans had been rallied by Apollo, who had been looking on from the citadel of Troy, the battle was renewed with increased fury. Perios, the leader of the Thracians, hurled a large, rugged stone, which struck the right leg of Diores, near the ankle, and crushed the tendons and bones. As Diores fell in the dust, with both hands stretched out to his comrades, Perios rushed upon him and plunged his spear into his bowels, so that all his entrails gushed out upon the ground. Thoas, the Ætolian, rushed upon Perios, and drove his spear

through his breast into his lungs, and jerking the spear from his breast and drawing his sharp sword, plunged it into his belly, and in turn deprived him of life. But he did not strip his fallen foe of his armor, for the Thracians, closing over it, drove back Thoas. And in a similar manner Homer describes the fierce and bloody contest of many other Grecian and Trojan heroes, and has thus given a most graphic, and, as far as the testimony of other ancient writers extends, a most truthful picture of ancient battles.

It appears, therefore, that in the battles of former times, few or no wounded survived, and the prisoners which were captured were either immediately destroyed or sold as captives. In the wars carried on between the Israelites and the surrounding nations, persons of rank were frequently reduced to the most degrading slavery; some prisoners were put under saws and harrows of iron, and made to pass through the brick-kiln; others were beheaded, or mutilated in various ways; mothers were murdered with their children; pregnant women were ripped up, and infants were dashed against the stones. And amongst the Romans, prisoners were frequently sold to the infamous schools for gladiators.

Time at which regular army surgeons were first employed, as well as the first establishment of hospitals, points of interest in the discussion of the origin of hospital gangrene. With the Hebrews and Egyptians, the art of healing committed chiefly to the priests. Great value of the hygienic laws of Moses.

The time at which regular army surgeons were first employed, as well as the date of the establishment of hospitals for the treatment of the wounded and sick generally, are points of interest in the discussion of the origin of hospital gangrene. With the Hebrews, as well as among the Egyptians, the art of healing was committed chiefly to the priests. Moses, who was reared in the court of the prince of Egypt, and instructed in all the knowledge of the wise men, and of the learned Egyptian priesthood, has left a most valuable monument to the history of medicine. The writings of this great lawgiver and statesman contain hygienic rules of the highest sagacity, designed to regulate not only the intercourse of the sexes, but also to prevent the origin and spread of contagious diseases amongst the hosts of Israel. As the Hebrew priests accompanied the armies to battle, it is probable that their ministrations to the wounded were of a physical as well as of a spiritual nature. The careful precepts of the Hebrews regarding personal cleanliness in all, whether healthy or diseased, as well as the free use of oil and wine upon wounded surfaces, would appear to have been eminently calculated to favor the speedy recovery of the wounded, without the supervention of the diseases which so often infest modern military hospitals. The instructions of Moses

regarding the signs of the leprosy and of other contagious diseases, and the measures to be adopted to prevent their origin and spread amongst the people, are certainly most accurate and minute. Many of the expressions of the sacred writers indicated that they were acquainted with unhealthy and even gangrenous sores and wounds; and some of these descriptions would apply with force and accuracy to the severest forms of hospital gangrene.

Whatever doubts may be entertained concerning the knowledge of profane writers, it is evident that the divine legislation made ample provision against the danger of contagion, as appears not only by the many laws against any communication with those afflicted with diseases, and especially sores and ulcers, deemed unclean, but also by the extreme caution with which all intercourse was prevented with other nations.

In ancient times physicians frequently accompanied and ministered to the leaders of armies. Homer's account of the wounding of Menelaus and the surgical skill of Machaon.

That physicians frequently accompanied and ministered to the leaders of armies at an early period, may be established by many facts. Thus Homer, in his account of the wounding of Menelaus by the barbed arrow of Pandarus, represents the king Agamemnon as calling for a surgeon to probe the wound, and apply medicaments to allay pain. Machaon, son of the famous Æsculapius, who, in response to the call of Agamemnon, extracted the arrow, squeezed out the blood, and sprinkled upon the wound soothing medicaments which Chiron of old had kindly given to his father, is presented by Homer in the light of a warrior and hero as well as of a surgeon.

Alexander the Great studied medicine, and was accompanied in his wars by regularly appointed physicians.

According to Plutarch, Alexander the Great was assisted in the study of physic by Aristotle, and not only loved the theory, but also the practice, and prescribed for his friends medicines and a proper regimen. And it is evident from the account given by the historian of the illness of the great conqueror, in Cilicia, supposed to have been caused by bathing in the cold waters of the river Cydnus, that Alexander was accompanied by regularly appointed physicians.

The physicians are represented as consulting together, fearing to administer medicine to the king in his dangerous illness, lest in case of a fatal termination they should be accused of poisoning; and the life of Alexander was said to have been saved by the bold and timely ministrations of Philip, the Acarnanian physician. The fears of the physicians appear to have been well founded; for Alexander himself crucified the physician Glaucus, after the death

of Hephæstion, a favorite soldier and officer, who, when sick of a fever, took the opportunity, whilst Glaucus was gone to the theatre, to eat a roasted fowl and drink a flagon of very cold wine, in consequence of which he grew worse, and died a few days after. It is clear, also, from Herodotus, that Darius kept around him the most learned physicians of foreign countries. Shortly after the overthrow of Orœtes the Persian, Darius, in leaping from his horse while hunting, twisted his foot with such violence that the ankle joint was dislocated. Thinking that he had about him those of the Egyptians who had the first reputation for skill in the healing art, Darius made use of their assistance; but, by twisting the foot and using force, the Egyptian physicians made the evil worse, and the pain was so great that he lay seven days and nights without sleep. On the eighth day, as the king still continued in a distressed state, some one who had before heard of the skill of Democedes the Crotonian, made it known to Darius, who ordered him to be brought as quickly as possible. This physician, by using Grecian medicines, and applying lenitives after violent remedies, caused the king to sleep, and in a little time restored him to health, though he had before despaired of ever recovering the use of his foot.

Darius kept around him the most learned physicians of foreign countries.

The surgical skill of Democedes was still further attested by the cure of Atossa, daughter of Cyrus and wife of Darius, who had a tumor on her breast, which after some time burst and spread considerably. As long as it was small, she concealed it, and from delicacy informed no one of it; when it became dangerous, she sent for Democedes.

In Greece and Asia Minor, physicians were held in high esteem; for, not to mention the divine honors paid to Æsculapius, who was considered as the father of the healing art, there was a law at Athens that no female or slave should practice physic, and in one of the states a law was enacted, that if any one during his illness should drink wine contrary to the orders of his physician, even if he should recover, he should be put to death for his disobedience. At various times medals were struck off in honor of different persons belonging to the medical profession; and it appears that the same honors were conferred upon Hippocrates by the Athenians, as had before been given to Hercules; he was voted a golden crown, publicly initiated into the Eleusinian mysteries, and maintained in the Prytaneum at the state's expense. Under the Roman emperors, we find the term *Archia'ter*, which has been

interpreted to signify either the "chief of the physicians" or the "physician to the prince." Without entering into any discussion as to the real signification of the word, or into any critical examination of the offices of the two classes of Archiatri (*Archiatri sancti palatti*, who were supposed to attend the emperor, and *Archiatri populares*, who attended on the people), it appears that special physicians, who had attained the highest rank in their profession, were chosen to attend the emperors, and were distinguished with special privileges and great honors.

In the Roman empire special physicians, who had attained the highest rank in their profession, were chosen to attend the emperors.

It would appear that at a comparatively remote period, the Roman armies were furnished with regularly appointed physicians, with determinate duties. *Medicus cohortes* and *medicus legioni* are said to appear in ancient inscriptions; and Salmasius, in noticing a passage about an army physician, *exercitus medicus*, in the work of Achilles Tatius, who lived about the third century of the Christian era, says that each cohort had in general a physician. In the sixth century, the emperor Mauricius had attached to his army *deputati*, who were distributed amongst the cavalry, and were obliged to carry off those wounded in battle. They had on the left side of the saddle two stirrups, in order that they might more easily take up the wounded behind them; and for every person thus saved, they obtained a certain reward. They were also obliged to carry a bottle containing water, for the purpose of reviving those who might have fainted through loss of blood. The emperor Leo VI., in the ninth century, mentions, besides the officers necessary for each band or company of a regiment, the deputati, physicians, and attendants on the sick.

The Roman armies furnished with regularly appointed physicians at a comparatively remote period.

We know but little beyond the bare fact that the Roman armies were provided with a medical staff, and little or nothing of the diseases of the sick and wounded soldiers who fell to their care.

The employment of appointed physicians in armies appears to have fallen into disuse with the decline of the Roman power, and the first Christian armies of the Middle Ages appear to have been without any medical organization; the various celebrated physicians who were present at the battles and sieges of those times appear to have served, not in an official capacity as army surgeons, but as soldiers.

The employment of appointed physicians in armies fell into disuse with the decline of the Roman power.

It was not until the fifteenth century that the attempt was made

to furnish some of the European armies with medical organizations. In fact, notwithstanding the efforts of the Germans, and of Henry V. of England, and of Ferdinand and Isabella of Spain, no very efficient organization was established until the time of Gustavus Adolphus, who appointed four surgeons to each regiment, which he reduced from the number of two or three thousand, first to twelve hundred, and afterwards to one thousand and eight. We cannot look to the barber surgeons to whom these armies were intrusted for any very accurate accounts of the various diseases.

In the 15th century the attempt was made to furnish some of the European armies with medical organizations.

As far as our knowledge extends, there were no organizations for the treatment of sick and wounded soldiers, and of the sick generally amongst the ancient Greeks and Romans, corresponding to the military and civil hospitals of the present day. When the sick were carried to certain temples, as that of Æsculapius, they looked chiefly to supernatural means for restoration. The Asclepiadæ or priests attached to the worship of Æsculapius, formed a particular caste, governed by sacred laws, like the priests of Egypt, and they were not permitted to reveal sacred things except to the elect; and strangers were admitted to this knowledge only after having submitted to the tests of initiation.

No organizations for the treatment of the sick and wounded amongst the ancient Greeks and Romans, corresponding to the civil and military hospitals of the present day.

Temples of Æsculapius.

"The temples of the god of medicine were generally very salubriously situated; sometimes on the summit of a hill, or the declivity of a mountain; sometimes on the shore, somewhat distant from the sea, and near to a thermal spring, or fountain of living water. Groves of trees refreshed the sight of the sick, and afforded them cool and solitary retreats in their beautiful and spacious avenues. The people came from all quarters on pilgrimages to these places, sacred to the god of medicine. The sick and the convalescent found there both agreeable and healthful diversions. The wholesome regimen to which they were subjected, the pure and temperate air they breathed, the faith and hope by which some of them were animated, the miraculous cures that were testified to, all united to affect their minds agreeably, and exercise a happy influence on their constitution. Besides these hygienic means, the Asclepiadæ employed special remedies appropriate to each disease, according to the notions they then had of it. They prescribed, according to circumstances, venesection, purgation, vomits, friction, sea-bathing, and mineral waters; in a word, they neglected none of the therapeutical means they possessed in those times.

"Knowing the great influence of the *morale* or the *physique*, these priest-doctors employed every means to control the imagination of their patients. These were not permitted to interrogate the oracle, until they

were purified by abstinence, fasting, prayers, and sacrifices. When all these purifications were accomplished, the consultants were introduced to receive the response of the oracle. Sometimes they were obliged to lie in the temple for one or more nights. Sometimes the god spake in a mysterious manner, without showing himself to the eyes of the faithful; sometimes he appeared to them under the form of a serpent, devouring the cakes on the altar; again he manifested his will in dreams, which were interpreted by the priests.

"The patients who recovered, went to their homes blessing the divine author of their recovery, and leaving behind them testimonials of their gratitude. Those who received no beneficial nor favorable response, believing that their offerings were rejected because insufficient, redoubled their zeal and their liberality. So that bad as well as good results added equally to the glory of the god, and the profit of his ministers.

"There existed in the country about Epidaurus, and in various other localities, serpents of a yellowish-brown color, whose bite was not venomous, and which were easily tamed. The priests employed them in those supernatural performances which filled the people with astonishment and superstition. Aurelius Victor relates, 'that during the year 350 of the foundation of Rome, the city was ravaged by a terrible pestilence; the Senate sent six deputies to consult the oracle of Epidaurus. After they had arrived at the temple, and were admiring the colossal statue of the god, suddenly an enormous serpent issued from beneath the pedestal. The sight of it impressed every mind more with veneration than terror. He moved tranquilly through the astonished crowd, and entered the vase of the Romans, in the chamber of Ogulnius, the chief of the ambassadors. The sacred reptile was piously borne away, and when the vessel of the ambassadors was approaching the city of Romulus, he sprang into the waves and swam to an island in the Tiber. A temple was immediately erected to Æsculapius on that spot, and the pestilence ceased.'

"Many other grave historians of antiquity report the prodigies effected by the intervention of the god of medicine. Nevertheless, every one did not credit them, as witness the testimony of the valet to whom Aristophanes, in one of his comedies, attributes the following language: 'The priests of the temple of Æsculapius, after having extinguished all the lights, told us to go to sleep, adding, that if any one should hear a hissing, which indicated the arrival of the god, he should not move in the slightest manner. So we all laid down without making any noise; but I could not sleep, because the odor of an excellent broth, that an old woman held near me, agreeably excited my olfactories. Desiring most ardently to slide along to it, I raised my head very quietly, and saw the sacristan, who took away the cakes and figs from off the sacred tables, going the round of the altars, putting into

his sack everything he could find. I believed that I had a right to follow his example, so I raised to go to the old woman's pot.'"[1]

Whilst the temples of Æsculapius resembled more nearly the dispensaries of the present day, in which advice was given and remedies administered, and formed an admirable field for the training of the young priests in the practice of medicine, as is evident from the great reputation of the schools of medicine of Rhodes, Cnidus, and Cos, it does not appear that the votive tablets fastened to the walls and columns of the temples after the manner of the Egyptians, contained anything more than the name of the patient, and such a terse and exaggerated description of the disease and its cure as would excite the wonder and superstition of the multitude, and herald the wonderful powers of the god of medicine. This view is sustained by the following inscription on one of these tablets, found at Rome, on the island in the Tiber, the site of an ancient Æsculapian temple: —

"Lately a certain Caius, who was blind, came to consult the oracle. The god required that he approach the sacred altar to perform adorations; at once he passed from the right to the left, and having rested his fingers on the altar, he raised his hands and applied them to his eyes. He recovered his sight immediately, in the presence of the people, who rejoiced to see such marvels accomplished under the reign of our august Antonius.

"Lucius was attacked with a pleurisy, and every one despaired of his life. The god ordered that the ashes of the altar be taken, mingled with wine, and applied to his side. He was saved, and gave thanks to God before the people, who congratulated him.

"Julian vomited blood, and appeared lost beyond recovery. The oracle ordered him to take the pine seeds of the altar, and eat them for three days, mingled with honey. He did so, and was cured. Having solemnly thanked God, he went away.

"The god gave this direction to a blind soldier named Valerius Aper: Take the blood of a white cock, mingle it with honey, and make a collyrium, which you are to apply to the eyes for three days. The soldier having fulfilled the direction of the oracle, was restored to sight, and returned to make a public thanksgiving to God."

The sick brought to Bethesda, looked to supernatural aid in the cure of diseases.

Bethesda (house of mercy), with five porches, was a place in Jerusalem, to which the sick were brought to await the moving of the waters, and we have no record of any organization for the care and treatment of those waiting for stated periods of cure; and these sufferers, like those who repaired to the temple of Æsculapius, appeared to

[1] Renouard.

look to supernatural help in the cure of their diseases. And it is further worthy of note that this Jewish house of mercy was located near a spring or pool of water, just as the temples of Æsculapius were situated in many places near mineral springs, to which the afflicted resorted.

Hospitalia of the Romans, and other asylums.

The Hospitalia of the Romans were small erections on the right and left of the main house, and corresponded with our inns.

The buildings for the aged women of Delos, erected on the island called Rhene, the institution which Antoninus built at Epidaurus, and the institution which is said to have existed on the island of the Tiber at Rome, to which sick slaves were brought, were most probably similar in some respects to asylums.

The view that the Taburna Meritoria was a house or hospital, in which Roman soldiers disabled by wounds, or worn out by the fatigues of war, were received, does not appear to be well founded. That the Grecians and Romans paid some attention to the welfare of their soldiers rendered unfit for service either by wounds or old age, is evident from the fact, that Solon deducted something from the pay of soldiers, and employed it for the education of children whose fathers had fallen in battle, in order that others might be encouraged to bravery. Pisistratus made an order that those who had lost any of their limbs in war, should be maintained at the public expense; and many instances may be found, some of which occur in the Justinian and Theodosian Codes, of the attention paid by the Romans to their Milites Causarii, who were not only exempted from taxes, but frequently obtained lands and cattle and money, and were sometimes assigned over to be taken care of by rich families and communities.

Hospitals as well as many other benevolent institutions first introduced by Christianity.

Hospitals, as well as many other honorable and benevolent institutions, were first introduced by Christianity. This divine religion not only dispelled the ignorance and prejudice which had so long shackled the human mind, but it taught the value of health and life, enlarged the bounds of knowledge, by leading to operations on the living subject, and dissections of the dead; and to the same benevolent source may be referred the numerous hospitals which are everywhere opened for the reception of the diseased and unfortunate, and those charitable institutions which constitute the glory of modern times. So early as the Council of Nice, A. D. 325, hospitals are spoken of as commonly known. The first celebrated hospital, is said to have been built at Cesarea, A. D. 370–380, and

was richly endowed by the Emperor Valens, and was of immense dimensions. After it followed the hospital of Chrysostom at Constantinople. In the fifth century, Fabiola, a Roman lady, the friend of St. Jerome, is said to have built one of the first houses for the reception of the indigent sick. Hospitals were established at an early date in Persia and Arabia. Thus Georgius, an author quoted by Rhazes, was director of the hospital and medical school at Jondisábúr, in Persia, about the middle of the eighth century (769). Georgius was succeeded in the charge of this hospital by his son, who took care of the institution when his father was sent to Bagdad by the Calif Al Mansúr.

As soon as pilgrimages to holy places, and especially to Palestine, became customary, as a part of religion, it was found necessary to build numerous resting-places, in which both the well and the sick might find entertainment. Brotherhoods were formed in the Holy Land, towards the end of the eleventh century, which undertook to provide for the wants of sick and indigent persons, and became richer and more numerous as the Crusades increased. Opulent persons when dying, bequeathed their property to these brotherhoods; and in this manner the hospitals in Palestine were constructed on a large scale, and were provided with better accommodations than those in Europe. They were even considered as models, and princes and rich persons returning safe from their pilgrimages caused similar ones to be established in their own countries. According to Matthew Paris, the number of lazarettos erected after the holy wars, amounted to 21,000. It is probable that the extreme prevalence of small-pox and other contagious diseases may have led to the founding of many of these hospitals; and we are told that the façade of one of these institutions exhibited a gibbet, for such as dare either enter or escape without permission.

The oldest hospitals, therefore, with the exception perhaps of the institution founded in Persia, by some Nestorian priests, as early as the seventh century, were established chiefly under the direction of the clergy, for the convenience and accommodation of the well, rather than of the sick. In the ninth century there were twenty-four hospitals in Rome alone.

In the earliest ages of the church, the bishop had immediate charge of the poor, both sound and diseased, also of widows, orphans, strangers, etc.; after fixed revenues were allotted to the churches, it was decreed that at least one fourth part should go to the relief of the poor; and to provide for them more commodiously,

houses of charity were built, which were afterwards denominated hospitals. At first these institutions were governed wholly by the priests and deacons, under the inspection of the bishop. In course of time, separate revenues were assigned for the hospitals; and particular persons, out of motives of piety and charity, gave lands and money for the erecting of hospitals. The priests gradually converted the hospitals into a sort of benefices, which they held at pleasure, appropriating the greatest part of the income to their own use. To remove this abuse, the Council of Vienna expressly prohibited the giving any hospital to secular priests in the way of benefice, and directed the administration to be given to sufficient and responsible laymen, who should take an oath for the faithful discharge of their duties. This decree was executed and confirmed by the Council of Trent.

Hospitals exclusively devoted to the treatment of the sick, with appropriate medical officers, were not established until the eleventh century. In fact, in many of the large hospitals, long after the beginning of the eleventh century, there were no regular medical organizations; and in the large hospitals of Jerusalem, the knights and brothers attended the sick themselves, and bound up each other's wounds, and exerted themselves to obtain the best balsamic mixtures; and in the houses for the sick belonging to the order of Templars, the duties of physicians and surgeons were not defined until near the middle of the fifteenth century. Many of the oldest European hospitals now existing are said not to date back beyond the seventeenth century; the Hôtel des Invalides of Paris was not commenced until the year 1670, by Louis XIV.; the English hospital at Chelsea was founded by Charles II., in 1682.

Hospitals exclusively devoted to the treatment of the sick, with appropriate medical officers, established in eleventh century.

From the facts which we have now presented, concerning the mode of warfare of the ancients, the imperfection of their medical knowledge, and of their arrangements for the treatment of the sick of their armies, and the comparatively modern origin of military and civil hospitals, we are justified in the statement that the mere absence of special descriptions is no proof that hospital gangrene is not a disease of great antiquity. The essential conditions for the origin and spread of this disease were frequently present in ancient as well as in modern times.

The preceding investigation furnishes no proof that hospital gangrene is of recent origin.

A disease similar in all respects to hospital gangrene appears to have been known to the most ancient writers.

Hippocrates mentions phagedænic spreading ulcers, and describes

both moist and dry gangrene, and gives valuable observations upon the treatment. In the Third Book on "Epidemics," Hippocrates describes a malignant season, in which many cases of erysipelas occurred from various causes, such as accidents or small wounds, in which great inflammation took place, the erysipelas quickly spreading over large portions of the body. This state was attended with abscesses and extensive suppurations, ending in destructive sloughing of the flesh, tendons, and bones. In the worst cases, the diseased parts discharged no pus, but underwent a sort of putrefaction, which laid bare the bones. In some cases, the fore-arm and arm were destroyed, and fell off; in others, the whole femur and bones of the leg and foot were laid bare. The most formidable cases were those in which the pubes and genital organs were involved in the gangrenous inflammation. The greater number of these erysipelatous cases, attended with moist gangrene, took place in the spring, but were prolonged through the summer and during the autumn, and happened in fevers and without fevers. Amongst other similar cases, Hippocrates mentions that of a boy attacked by a phagedænic ulcer, which caused the lower teeth, and the fore teeth of the upper jaw, to fall out, leaving deep cavities. In connection with this case, Hippocrates observes that when the bone of the palate comes away, the nose sinks in the middle, and when the upper fore teeth fall out, the end of the nose becomes broad. Hippocrates employed the cautery and stimulating applications for the arrest of phagedænic ulceration and gangrene, and makes mention of arsenic, verdigris, flowers of copper, frankincense, myrrh, hellebore, etc., as suitable for the cleansing of foul ulcers. This author also dwells upon the beneficial effects of causing foul gangrenous ulcers to bleed, on the ground that it is the blood especially which prevents such ulcers from healing, by getting into a state of putrefaction and corruption.

Hippocrates describes phagedænic spreading foul ulcers.

Pliny, in that portion of his "Natural History" which treats of the remedies derived from plants and animals, has mentioned various kinds of ulcers; as phagedæna, which he described as an ulcer cacoethes; serpiginous ulcers, the cure of which Pliny considered more than doubtful; corrosive sores, putrid sores, callosities or putrid sores, corrosive sores known as *noma*, defluxions, apostemes, sordid ulcers, suppurations, abscesses, fistulous ulcers, and gangrenes; also, contused and incised wounds, and simple and compound fractures. Pliny also recommends various remedies, as the juice of the Tithymalos Char-

Various kinds of ulcers and putrid sores mentioned by Pliny.

acias, bull's gall, leek juice, woman's milk, bull's blood dried and pounded with the plant Cotyledon, and ashes of cow's hide mixed with honey, for the cure of gangrenes, phagedænic sores, and putrid ulcers.

Galen an authority on mortification.

After Hippocrates, Galen is regarded as the great ancient authority on mortification, and from him, Oribasius, Aetius, Paulus, and all the subsequent writers on this subject are said to have copied. In his observations upon gangrenous inflammation, Galen appears to refer to the moist or hospital gangrene of the present day, and recommends the free excision of the gangrenous parts, and the application of the actual cautery to the cut surfaces. After this treatment, poultices were to be applied to favor the separation of the eschar. Free incisions in the sound skin around the gangrenous parts were also recommended; and after the manner of Hippocrates, Galen advocates those measures which will promote free hemorrhage, on and around the gangrenous and inflamed parts, in order to relieve the congested blood-vessels, and to remove the stagnant blood which he considered as the cause of the gangrenous inflammation, and at the same time to promote the free circulation of the air in and around the gangrenous parts. We now know not only that bleeding is beneficial when it takes place in moderation from the gangrenous surface, but that oxygen is a valuable agent in the treatment of foul ulcers.

Important researches of Mr. Blackadder on the history of phagedæna gangrænosa.

Mr. Blackadder, in his valuable "Observations on Phagedæna Gangrænosa," has shown that several of the ancients in their descriptions of foul gangrenous bleeding ulcers, must have alluded to the same kind of disease which is now usually denominated hospital gangrene; and that besides the use of the actual cautery, several of the older writers, as Aetius, Celsus, Paulus, Rolandus, Avicenna, Guido, and others, employed, for the cure of such ulcers, arsenical preparations.

Celsus describes the disease.

Celsus, who flourished in the first century, under Augustus and Tiberius, distinguishes those species of ulcer which heal by common applications after sloughing, from those which spread either by phagedæna or a succession of sloughs. For the cure of the common phagedæna, Celsus advises the actual cautery. The other variety of spreading ulcer he describes as beginning with a blackness or slough, and if not arrested, causing extensive destruction of tissue; and if this sloughing reach important organs as the bladder, no assistance can be given. If the sloughing is situated on the glands near the urethra, he advises the actual cautery, with proper care [illegible] of the urethra; but

if the disease has penetrated deep, that the knife should be used. But even allowing that Celsus may have confounded, in his description, cancerous ulcerations and certain forms of spreading venereal sores, it must at the same time be granted, that he refers to a species of morbid action, which, to say the least, bears a very close resemblance to hospital gangrene.

Aretæus does not mention the disease.

Aretæus, the Cappadocian, who was probably a contemporary with Galen, in those portions of his works which have come down to us, whilst alluding to gangrene following the introduction of the catheter into the bladder, and to the spreading phagedænic gangrenous ulcers of dysentery, makes no mention of the disease under consideration.

Observations of Aetius in the 5th century.

In the works of Aetius, who wrote in the fifth century, are found various though brief references to a disease differing in no respect from hospital gangrene; and in its treatment the cautery is recommended, after milder remedies had been tried and found to be ineffectual. The following is an example of one of his more active applications: ℞. Mysyos crudi, Chalcitidis crudi, ā. ʒviij; Ochræ, ʒiij; Sandarachæ, ʒiv; Calcis, ʒij; Squamæ æris, Aluminis, ā. ʒij; Diphrygis, ʒiv ℔. It has been observed by Mr. Blackadder, with reference to this prescription, that the native red sulphuret of arsenic was called Sandaracha by the Greeks, Realgar and Resigal by the Arabians. The name arsenic was restricted, by the former, to the Auripigmenta, or native red and yellow sulphurets, when they had the form of thin leaves or scales.

The early writers used a number of terms to describe ulcers.

In the writings of early authors, the terms putrid, corrosive, cancerous, phagedænic, malignant, virulent, etc., as applied to ulcers, were not strictly employed as distinctive appellations of different species of sores, but rather as terms descriptive of certain changes that were liable to occur; so that a sore which was strictly termed sordid one day, might with equal strictness be termed sordid and depascent the next; the third day it might be termed malignant or virulent, the fourth putrid and corrosive, or otherwise, as the peculiar symptoms might indicate. Mr. Blackadder has also shown that the appellations Cancer, Herpes esthiomenus, Ignis Persicus, Erysipelas, and even Carbunculus, Noli me tangere, and Lupus, were also very differently applied by different authors; and hence it is only by comparing the descriptions and treatment of similar diseases that are found in the same author, with one another, and likewise with those that are to be met with in other authors, that we can arrive at any certain knowledge of the particular diseases they refer to.

Paulus Ægineta, who wrote in the seventh century, follows Galen very closely in his description of mortification. Paulus gives in his Fourth Book various observations upon the nature and mode of treatment of sordid, putrid, and phagedænic ulcers, but we discover nothing new in the slavish imitations of these compendious writers. Rolandus, an author of the twelfth century, has in his Third Book, on "Wounds," a chapter with the following title: "De Carbunculo superveniente vulneri." Belloste, when speaking of the bad effects of the air on wounds, refers to gangrenous phagedæna as a species of carbuncle. These carbuncles, he says, are occasioned, as some think, by the arsenical particles in the air, which, being taken in by respiration, are thrown out by the strength of the natural heat, upon some emunctory. Avicenna, an author of the eleventh century, in his Commentaries, refers to a disease resembling in most respects hospital gangrene, and recommends arsenical applications. Descriptions of putrid, corrosive sores, resembling hospital gangrene, exist in the works of Rogerus, Brunus, Theodoricus, Lanfrancus Bertapalia, and Guido, authors of the thirteenth and fourteenth centuries. Alphonsus Ferrus, who published in 1534 one of the first treatises on gunshot wounds, was of opinion that gunshot wounds were poisoned by the gunpowder. From his description, it appears evident that he had been witness to the supervention of hospital gangrene. In the work of Dr. Blackadder, from which some of these historical notices have been drawn, the reader will find in the second part, pages 69–160, ample quotations illustrating the views of the authors just referred to, also of others, as Ambrose Paré, Wiseman, and G. Horstius.

Observations of Paulus, Rolandus, Avicenna, and other authors.

Paré, more than two hundred and fifty years ago, says that in the siege of Rouen the air was so noxious that no wounds would heal; and the besieged, finding that all their wounds became gangrenous, reported that the besiegers had poisoned their balls; the besiegers also, seeing none but putrid sores in the camp, believed that their wounds were poisoned; and, both within and without the city, such was the state of the air, and so putrid were all the wounds, that the surgeons could scarcely look upon the sores or endure the smell; and if they neglected them for a single day, they found them full of worms. Paré complained that in the Hôtel Dieu, sores would not heal, and no operations could be rightly performed. And after him Diorus, more than one hundred and fifty years ago, protested against performing operations in the Hôtel Dieu, and advised that

Gangrenous state of wounds at siege of Rouen described by Paré.

a hospital should be built in the environs of the city, for those who were wounded or required operations. And other army surgeons of former times have remarked, that in some seasons those wounded in battle and those operated upon become affected with gangrene, and however trifling the wounds at first sight might be, the patients usually fell victims to the gangrenous affections which ensued.

Description of putrid ulcers by Wiseman.

Wiseman, in speaking of putrid ulcers, says: "The sign of a sordid ulcer is a tough excrement sticking to it, with great heat and pain. As the sordes increaseth, it changes its color; and the ulcer corrupts and the matter stinks. If, from abundance of sordes, transpiration be hindered, a corruption of the part follows, and it terminates in a corrosive or putrid ulcer; and if the putrefaction be not checked, a gangrene and sphacelus follows." This celebrated writer describes two kinds of phagedænic ulcers, under the names of phagedæna and noma. "Both these are venemous, malignant ulcers, and both spread; but they differ, in that one hath tumor and no putrefaction, the other putrefaction and no tumor."

European army and navy surgeons acquainted with hospital gangrene at an early day.

The extensive wars in which the different nations of Europe have been from time to time engaged, have afforded medical officers frequent opportunities of treating hospital gangrene, and there can be but little doubt but that the surgeons, especially of France and England, were acquainted with this disease at an early period. It would appear that in the British navy, hospital gangrene has long been confounded with scurvy and scorbutic ulcers. G. Fabricius, Roetenbeck, Horn, Van der My, Rolfink, Maulenbrocius, Camerarius, G. Horstius, Woodall, Gideon Harvey, Anson, John Huxham, John Hunter, Lind, David Macbride, Sir Gilbert Blane, Thomas Trotter, and others, have recorded valuable observations upon the foul gangrenous ulcers of scurvy, which will be examined under the different divisions of the following investigations.

Various other authors have described the disease.

Lamotte, in 1722, mentions hospital gangrene as being known in the Hôtel Dieu, of Paris, by the name of *la pourriture*, and as a disease which attacked the wounds inflicted by operations, and the ulcers and abscesses of those who breathed the corrupted air of this hospital.

A description of hospital gangrene as a distinct disease appeared in 1783, in the third volume of the posthumous works of M. Pouteau, chief surgeon to the Hôtel de Dieu, of Lyons. The attention of this author was directed to the disease by having been

himself affected with it, while employed as dresser in the hospital. M. Dussassois, the successor of Pouteau in the same hospital, published in 1788 an account of this disease, in a pamphlet of about ninety pages. This was followed shortly after, in 1796, by a small pamphlet upon this disease, by Moreau and Burdin. An excellent account of this disease appeared in the sixth volume of the London "Medical Journal," in 1785, and was entitled "Observations on the Putrid Ulcer; by Leonard Gillespie, Surgeon of the Royal Navy." The sore described by Dr. Rollo, in his work on Diabetes, published in 1797, in the section entitled "A Short Account of a Morbid Poison acting on Sores, and of the Method of Destroying it," is evidently one and the same disease with hospital gangrene. We shall not prolong this historical notice by an attempt to give an analysis of the results of the labors of the various physicians who have written upon this disease, but will endeavor to introduce the observations of value under the appropriate divisions of our labors, contenting ourselves at present with the following bibliographical list: —

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CHAPTER FIRST.

OUTLINE OF THE SYMPTOMS AND CHANGES CHARACTERISTIC OF HOSPITAL GANGRENE, AS IT HAS MANIFESTED ITSELF IN THE CONFEDERATE ARMIES.

Outline of the Symptoms and Changes characteristic of Hospital Gangrene, as it has manifested itself in the Confederate Armies. — Constitutional Disturbances amongst the Earliest Symptoms of Hospital Gangrene. — Difficulty of determining whether the Fever was the Resultant or the Cause of the Early Changes in the Wound. — Observations of Dr. Rollo in the Artillery Hospital at Woolwich. Views of Mr. Blackadder, who held that Hospital Gangrene was only communicated by the Direct Application to a Wounded Surface of the Infectious Matter, and that the Local Symptoms precede the Constitutional. — Views of various other Writers upon the Relations of the Local and Constitutional Symptoms of Hospital Gangrene; of Delpech, Baron Boyer, Dr. Thomas Trotter, Thomas Moffat, John Thomson, Hennen, Thomas Clark, James Copland, H. B. Macleod. — In its Mode of Origin, Hospital Gangrene may be viewed in Four Different Ways: 1. As a Local Disease, communicable only by Contact with Animal Matter in a Certain Stage of Change or Decomposition; 2. As a Constitutional Disease; 3. As both Local and Constitutional in its Origin; 4. The Disease may arise from the Action of a Specific Poison, which acts in a Manner similar to that of Small-pox, Measles, or Scarlet Fever. — Hospital Gangrene may arise in those exposed to the Exhalations from Gangrenous Wounds, without any Abrasion of the Surface. — Illustrative Cases. — Observations of Dr. Trotter. — Hospital Gangrene can be communicated through the Atmosphere to Wounded Surfaces without any Direct Application of the Matter.— Extensive Prevalence of the Disease amongst the Wounded sent to Augusta, Ga., after the Battle of Chickamauga.— Effects of Crowding and Bad Air.— Testimony of Surgeon D. J. Roberts, of 20th Tennessee Regiment, Tyler's Brigade, with Reference to the Origin of Hospital Gangrene amongst the Confederate Wounded captured by the Federals after the Battle of Jonesboro'. — Case related by Surgeon E. N. Covey. — In some Cases after the Wounds have been subjected to the Action of the Cause of Hospital Gangrene, a considerable Period of Time elapses before the Disease appears; Illustrative Cases. — Case reported by Assistant-Surgeon F. A. Anderson. — Rapid Action and Spread of Hospital Gangrene amongst the Dejected, Diseased, and Filthy Prisoners crowded into the foul Prison and Hospital at Andersonville. — Period of the Incubation of Hospital Gangrene not fixed. — Views of Mr. Blackadder, of Baron Boyer, and Thomson. — The Establishment of the Facts that the Poison of Hospital Gangrene has no Definite Period of Incubation, and that it may arise de novo, at any Time, and that it may be communicated either through the Atmosphere, or by Direct Contact, is of Importance in its Bearings upon the Theory and Classification of the Disease. — Death resulting from the Rapid Poisoning of the System before the Local Disease has progressed to any Extent. — Observations of Mr. Guthrie, and Macleod. — Character of the Local Changes. — Illustrative Cases.

CONSTITUTIONAL DISTURBANCES AMONGST THE EARLIEST SYMPTOMS OF HOSPITAL GANGRENE.

Constitutional disturbances

In many cases the appearance of gangrene in the wounds was preceded by fever, which was sometimes ushered in by a chill. This fever was most commonly attended with loss

of appetite, depression of spirits, constipation of the bowels, and such an enfeebled, irritative action of the circulatory apparatus, as denoted a depression of the vital, nervous, and muscular forces.

amongst the earliest symptoms of hospital gangrene.

It has been difficult to determine whether the fever was the resultant or the necessary accompaniment of the early changes in the wound. It is, however, a point of interest in its bearing upon the determination of the nature of the disease, as well as upon the treatment, that the constitutional symptoms in many cases do precede such local changes as are sufficient to attract the attention of the patient and physician.

Difficulties of investigations to determine relations of constitutional and local disturbances.

The Confederate troops have been so often exposed to malarious influences, that it is impossible to determine in most cases the cause and nature of the chill which sometimes precedes the fever. Without doubt it was, in some cases at least, of malarious origin. When the system has been brought under the influence of malaria, any depressing cause, as a gunshot wound, especially if unfavorable changes are set up in the injured parts, may induce true chill and fever.

In the general hospitals attached to the Army of Northern Virginia, to the Department of South Carolina, Georgia, and Florida, and to the Army of Tennessee, I have seen a number of cases of extensive hospital gangrene in gunshot wounds, and in those resulting from amputation and various operations, in which the disease was said to have appeared as a local affection without any constitutional symptoms. Loss of appetite and febrile excitement was said to have been entirely absent, or else to have appeared only after the local disease had progressed to a considerable extent. These cases certainly manifested constitutional disturbances of the gravest character, when they passed under my examination; and in no case was I able to discover any accurate or critical record of the condition of the patients, and especially of the circulation, respiration, temperature, and of the alimentary canal and nervous system, in the earliest stages of the disease; such testimony to the exclusive local origin of hospital gangrene should, therefore, be regarded only so far as to excite careful observations and investigations upon the first recognizable symptoms. The question of the local or constitutional origin of hospital gangrene can be settled definitely only by extended and minutely recorded observations upon the whole progress of the disease from the first deviation from the condition of health.

It is important to consider this question well, because the best writers on this subject differ in their views, and because it is intimately connected with every theory of the origin and nature of the disease, and with the great practical question whether hospital gangrene is to be treated locally or constitutionally, or by both means combined. In attempting to settle this question by an appeal to authority, the great difficulty is the want of accurate and minute observations of the earliest symptoms preceding the actual appearance of gangrene. Thus, as far as our knowledge extends, no writer up to the present time has given any critical observations upon the changes of the temperature, and urine, and blood, at any period of the disease, and by the majority of writers even the changes of the pulse and tongue are noticed only after the establishment of the gangrene. The simple announcement that the disease commenced as a local affection, and manifested no constitutional symptoms until a certain period, should not be taken as a final decision. Such general statements should be sustained by critical observations upon the most obvious phenomena of the animal system. That we may, however, give this important subject the consideration which it demands, we will compare the testimony of some of the best writers on both sides.

In the hospital gangrene observed by Dr. Rollo in the Artillery Hospital at Woolwich, —

Observations of Dr. Rollo on the mode of origin of hospital gangrene; of the local and constitutional symptoms.

"The action of the poison seemed to be limited, and confined to specific effects; the first were local, producing only a general affection by a more extensive operation on the sore, and which in a certain time terminated in the healthful separation of parts, granulation and cicatrization, and state of constitutional convalescence. Five or six days from the appearance of the small ulcer or ulceration, when it had extended over one third of the former sore, with pain and redness in the course of the lymphatics, and the glands through which they led, with enlargement of them, general indisposition of the body became evident. This consisted in nausea, loss of appetite, heat of skin, a very small and quick pulse, extreme irritability, a whitish tongue, and thirst. When these symptoms took place, the ulceration rapidly went on, extending beyond the limits of the former sore, and destroying the adjacent parts. The operation of the poison in slowness or rapidity probably depended on some constitutional circumstance, as it was not in all of equal degrees of facility. These sores, which spread rapidly and extensively to sloughing, and even to gangrene, from one, two, or more small ulcerations, very likely happened in those who might be said to have a constitutional susceptibility; while,

The operation of the poison in slowness or rapidity depended upon some constitutional circumstance.

on the contrary, in those where the ulcerations continued distinct, and remained covered with a thick, whitish, and adhesive matter, without acquiring the sloughing and gangrenous states, their constitutions had no favorable tendency to the operation of the poison. Impressed strongly with the notion that a morbid poison was applied locally to a part of the sore, which, like the venereal poison, had the power of assimilation, and thus augmenting its power, as also of being absorbed, producing general effects on the system and a reaction on the sore, we were determined to adopt local means of treatment, consisting in the chemical destruction of the poison in parts under its direct action, and in exciting a new action."

The poison of hospital gangrene, like the venereal poison, not only acted locally, but had the power of being absorbed, and producing general effects upon the system, and reacting upon the sore.

Mr. Blackadder, who believed that hospital gangrene was only communicable by the direct application to a wounded surface of the infectious matter, declared that in no instance which he had an opportunity of observing, did the constitutional symptoms of gangrenous phagedæna precede the local, unless the case be held an exception, in which the stump became affected after amputation had been performed on account of the previous effects of the disease. According to this author, the period at which the constitution begins to exhibit symptoms of irritation is extremely irregular, sometimes as early as the third or fourth day, and sometimes even as late as the twentieth. Mr. Blackadder, from numerous cases of this disease observed at Passage, in Spain, drew the following conclusions: —

According to Mr. Blackadder, the constitutional disturbances always follow the local manifestations.

1. That the morbid action could almost always be detected in the wound or sore previous to the occurrence of any constitutional affection.

2. That in several instances the constitution did not become affected until some considerable time after the disease had manifested itself in the sore.

3. That when the disease was situated in the inferior extremities, the lymphatic vessels and glands in the groin were observed to be in a state of irritation, giving pain on pressure, and were sometimes enlarged before the constitution showed evident marks of derangement.

4. That the constitutional affection, though sometimes irregular, was in many cases contemporary with the second, or inflammatory stage.

5. That all parts of the body were equally liable to become affected with this disease.

6. That when a patient had more than one wound or sore, it

frequently happened that the disease was confined to one of the sores, while the other remained perfectly healthy, and that even when they were at no great distance from each other.[1]

The opinion is here clearly announced by Mr. Blackadder, that hospital gangrene is at first a local disease, which is not necessarily preceded or in the first stages accompanied by any constitutional derangement.

Delpech expresses similar views.

Delpech, in like manner, testified that the constitutional symptoms occurred always after the establishment of the local disease, and were therefore a consequent and not a cause of the local derangement.

Baron Boyer places the constitutional symptoms last in the order of succession.

Baron Boyer, whilst giving as causes of hospital gangrene the situation of the hospital in low, marshy ground, the vicinity of sinks, the filth of personal uncleanness, unwholesome food, crowded or unventilated wards, and in fact everything which destroys the purity of the air of the place where the patients are collected, — for air thus affected, he affirms, brings on this disease, even in the most simple wounds, by its effect not only on the surface of the wound, but also on the whole system, — at the same time places the constitutional symptoms as the last in order of succession. Thus, according to Baron Boyer, —

"The first symptoms of hospital gangrene are, pain in the wound, and a white, viscid coat on the surface of the granulations, which become paler, and present several grayish spots, resembling venereal ulcers, or apthæ. Commonly, these points of ulcerations in different parts of the primitive sore extend and unite, so that the whole mass assumes a grayish ash color, more or less hard, and sometimes bleeding; a purplish red color next forms on the adjacent skin, which becomes œdematous, and extends. Sometimes, when the patient is healthy, the disease goes no further, it may even affect only a part of the ulcer, but oftener its progress is extremely rapid and frightful; the edges of the wound become hard and everted; the granulations are raised and puffed up by the elevation of a large quantity of gas, with which they seem to be entirely filled, then they fall off by soft, reddish eschars, very like the putrid brain of a fœtus; the surface of the ulcer becomes putrid, and furnishes an abundance of sanious pus, extremely fetid. Until it be arrested, it extends either in superficies or depth, so that aponeurosis, muscles, blood-vessels, nerves, tendons, periosteum, and the bones themselves become its prey. As soon as the disease has reached a certain height, the patient loses his appetite; the tongue is covered with a white coat; a fever appears; the pulse is small, hard, and

[1] *Observations on Phagedæna Gangrænosa*, p. 19.

irregular; his agitation becomes general; he is anxious, sleepless, and disturbed."

On the other hand, Dr. Thomas Trotter, in the second and third volumes of his "Medicina Nautica," denies the infectious nature of this disease, which he calls malignant ulcer, and refers its existence to a peculiar state of the constitution: —

Dr. Trotter refers the existence of malignant ulcers to a peculiar state of the constitution.

"The operation of any specific contagion, either generated or imported, leaves us equally in the dark. If there had been such a cause, the mode of its application is beyond scrutiny; if it could act without actual contact, it must be of too subtle a nature to become familiar to our senses, and renders every attempt at explanation nugatory. The analogy of some other contagions, such as lues venerea, elephantiasis, lepra, psora, etc., cannot apply; for these have each their peculiar action, and their source is easily traced. Ulcers produced by punctures of dissecting instruments, and proving fatal, may be added to this account. . . . . Whether, therefore, a morbid poison, or a contagious matter, or any other cause, may be considered as producing this ulcer, it is clear from the history given in our ships, that there is a condition of body, at the time, which renders it susceptible of the noxious power, if this condition of the body be not of itself fully adequate for the whole. . . . . That there is a species of ulceration peculiar to a scorbutic diathesis, is a fact as well ascertained as any in the history of disease. That it is produced at sea, by a concurrence of causes, but chiefly by a deficiency of recent vegetable matter, we believe to be equally well established. This peculiar kind of ulceration in a scorbutic disposition does not always require the exciting power of external injury to begin it. We have seen and have been told that the cicatrix of an old sore breaks out afresh, and the callus of bones formerly broken is dissolved. Like the ulcer of our inquiry also, the disposition and character of the scorbutic sore are often engrafted on fresh wounds and old ulcers, from whatever cause, till in the end they occupy the whole ulcerated surface, and exhibit their own features only. A scrofulous disposition excites first inflammation, and then ulcers of its own kind. The secondary ulcers of the venereal virus are also produced by a habit of body beginning the diseased action. But the disposition to cancer, the most formidable of all ulcers, is first latent in the habit, and only in its latter stage appears with the character of an open sore.

"With all these analogies, therefore, before us, why should we deny that a disposition of body may not also be the main cause of one species of ulcer, and that the fresh wound, as in phlebotomy, the blister, the scald, and burn, with the common sore, were only so many diseased spots, where its action could be more easily put in motion than on the sound part of the constitution, that retained the preservative powers of

health to secure them against it. Dr. Rollo has told us that the morbid poison was first perceived in the edges of healing sores, as a distinct little ulcer, of a darkish color, its edges jagged, its bottom unequal and rugged, and discharging a thin matter, having a peculiar smell. Dr. Browne, in the 'Royal Sovereign,' remarked sores nearly cicatrized, displaying on the inner edge of the cicatrix a watery bladder, with a dark-brown or black spot in the middle. He emphatically adds, this was the focus whence the flame spread. Thus these accurate observers give similar evidence, in first detecting the beginning embryo; but this black or brownish spot, it is plain, must have undergone previous inflammation to make it appear in that color; and the fetid smell perceived, showed that the seat of it was now undergoing decomposition. We do not, therefore, find that there was any need of a foreign poison to excite this inflammation in a sore or wound, with constitutions in such high states of excitement as our patients have been found. The future progress of the ulcer, till the sloughing and fever are finished, is only this course on a large scale. It seems in its genius as an ulcer, what the epidemic of the West Indies is as a fever; the stages of high excitement and exhausted sensorial power follow one another so quickly that we have scarcely time to mark where the one finishes and the other begins." [1]

Mr. Thomas Moffat, in a communication to Dr. Trotter relating to the malignant ulcer, or hospital gangrene, dated on board the *Triumph*, at sea, 1798, states that—

Views of Dr. Trotter sustained by the observations of Mr. Moffat.

"For some days after the wound or other injury was inflicted, every thing went on well; when suddenly a violent fever came on, generally towards evening, and continued without any intermission for two or three days, sometimes a week, the sore meanwhile becoming inflamed and livid for a considerable distance around, throwing off very deep and fetid sloughs, of a grumous appearance, till the sore was twice its former size, with a ragged surface, as if gnawed by a dog, and high reflected edges. As it ceases to cast off sloughs, the fever subsides, and frequently both are over in two nights. After a length of time, more or less in different cases, when the sore had been brought to a healing state, it has frequently run the same course over again for several times successively." [2]

Dr. John Thomson, in his "Lectures on Inflammation," favors the view that the constitutional symptoms precede the local in hospital gangrene.

Dr. Thomson favors the view that the

"We know as yet, it is true, but little of the laws by which this contagion is communicated, or the distance to which it extends from the focus of infection. It would seem, however, to be

[1] *Medicina Nautica, an Essay on the Diseases of Seamen*, by Thomas Trotter, M. D. Second edition, 1804, vol. ii. pp. 211–215.

[2] *Ibid.*, vol. ii. p. 184.

capable of being communicated through the medium of the air; for it passes along the wards of an hospital, and attacks patients placed at some distance from one another. Nor is the time at which the disease begins to show itself, after the infection has been received, better ascertained. I think that I have repeatedly seen it attack patients in less than three days after they have been exposed to its influence, but of this I would not be very positive. We are also ignorant whether this poison can act immediately on the sores which it attacks, without being absorbed, or whether, like most other poisons, it must first be absorbed, and produce its effects afterwards, only through the medium of the general constitution.

constitutional symptoms precede the local in hospital gangrene.

"The symptoms by which malignant ulcer, or hospital gangrene, is characterized, are partly of a local and partly of a constitutional nature. These two classes of symptoms are not invariable in the order of their appearance, for sometimes the one and sometimes the other class seem to occur first in the order of succession. According to the result of my own observation, the constitutional symptoms usually precede the local. In the cases in which they have appeared to succeed the local, may not the constitutional symptoms, though they actually existed, have been so mild as to escape observation? In the progress of the constitutional symptoms, a general uneasiness is felt before any visible changes take place in the wound or sore which is attacked with hospital gangrene; the tongue becomes foul, with a sensation of bitterness in the mouth; the appetite decreases, and the patient begins to loathe food; the pulse becomes very quick, but is in general rather weak than strong; the skin feels hot, and the patient, in the progress of the disorder, becomes afflicted with great anxiety and restlessness."[1]

Dr. Hennen regarded the disease in its origin as constitutional, as well as local, and he appears to have placed more reliance upon internal remedies than upon external applications. According to this author, the disease, as it prevailed at Bilboa, commenced generally, in the case of wounds, with a sudden attack of severe pain in the head and eyes, tightness about the forehead, want of sleep, loss of appetite, a quick pulse, and other febrile symptoms, while the wound, which had been healthy and granulating, at once became tumid, dry, and painful, losing its florid color, and assuming a dry and glossy coat. If the incipient stage was overlooked, the febrile symptoms very soon became aggravated; the skin around the sore assumed a highly florid color, which shortly became darker, then bluish, and at last black, with a disposition to vesicate; while the rest of the

Dr. Hennen regards the disease in its origin as constitutional as well as local.

[1] *Lectures on Inflammation*, by John Thomson, M. D., etc. American edition. Philadelphia, 1817, pp. 364, 385.

limb betrayed a tendency to œdema. All these threatening appearances occurred within twenty-four hours; and at this period also the wound, whatever might have been its original shape, soon assumed the circular form. The sore now acquired hard, prominent edges, giving it a cup-like appearance, with particular points of the lip of a dirty yellow hue, while the bottom of the cavity was lined with a flabby, blackish slough. The gangrene still advancing, fresh sloughs were rapidly formed; the increasing cup-like cavity was filled up and overtopped by them, and the erysipelatous liver and vesication of the surrounding skin gained ground, while chains of inflamed lymphatics could be traced from the sores to the adjoining glands, there exciting inflammation and suppuration, which often furnished a new nidus for gangrene. The face of the sufferer assumed a ghastly, anxious appearance; his eyes became haggard, and deeply tinged with bile; his tongue covered with a brownish or blackish fur; his appetite entirely failed, and his pulse feeble and accelerated. In this stage the weakness and irritability of the patient was such that the slightest change of posture put him to torture, increased by his inability to steady the limb, which, if lifted from the bed, was seized with tremors and spasmodic twitches.[1]

Dr. Thomas Clark records the observation that the hospital gangrene which seized the English troops in the West Indies was ushered in with fever: —

According to Dr. Clark, the gangrene which seized the English troops in the West Indies was ushered in with fever.

"In the beginning of July, 1794, several hundred wounded men were received into the general hospital from Guadaloupe. For some time after admission, the generality of the wounded seemed to do very well. Speedily, however, the greater part of them were seized with more or less fever. The sores then assumed an unfavorable aspect; a violent inflammation generally took place, and was very often succeeded by mortification of the neighboring parts, of various degrees of extent in different instances. Upon the cessation of fever, the inflammation generally abated, and the mortification stopped. A separation of the dead from the living parts soon afterwards took place; and the sores now, though generally very much increased in dimensions, again put on a healthy appearance, and continued to mend until another attack of fever happened. A renewal of the phenomena lately mentioned then took place, generally more violent than at first, and necessarily left the patients' constitutions much impaired. In these climates, when men are reduced to a certain degree of debility, feverish attacks are very common, and

[1] Hennen's *Military Surgery*, second edition, pp. 214–216.

the condition of ulcers generally correspond with the other symptoms."[1]

Dr. Clark affirms that during his stay in the West Indies there was not a single instance, that fell under his observation, of a complete recovery after amputation, and, as far as he could learn, but one perfect recovery was effected in the general hospital, under like circumstances. All of the patients either died or were put on board hospital-ships for England. Hospital gangrene appears to have been one of the chief causes of this extraordinary mortality.

One of the most learned and able medical writers of the present day affirms, that although the fluids of the diseased part will produce hospital gangrene when they come in contact with an abraded surface, or possibly even when they are for any time applied to the sound skin, yet it is chiefly owing to the solution of putrid animal miasms in the humidity of the surrounding air that the disease is communicated in the wards of a hospital; the close and foul air generated by the discharges from suppurating or gangrenous surfaces will favor the production of gangrene in injured parts, by lowering vital power and deteriorating the circulating fluids, and thereby inducing a state of system similar to that in which putro-adynamic fever originates, or by which it is characterized.

Dr. James Copland holds that hospital gangrene is always attended with adynamic fever, and is often preceded by more or less depression of nervous and vital power, although rarely by prominent febrile symptoms.

Hospital gangrene is always attended by adynamic fever; and in the circumstances just alluded to, it is often preceded by more or less depression of nervous and vital power, although rarely by prominent febrile symptoms. Derangement of the digestive functions, sometimes diarrhœa, a quick and feeble pulse, and physical and mental depression, generally usher in and attend the early progress of this gangrene.[2]

Dr. Copland enumerates the following causes of this disease: —

1. A cachectic and debilitated state of constitution, generally connected with disorder of the digestive canal and liver.

2. A low, humid, and miasmatous atmosphere, and a damp and an ill-ventilated place of residence.

3. Insufficient or unwholesome food, and the use of impure water.

[1] *Observations on the Nature and Cure of Fevers, and of the Diseases of the West and East Indies, and of America*, etc., by Thomas Clark, Surgeon; 1801, pp. 118–120.

[2] *A Dictionary of Practical Medicine*, etc., by James Copland, M. D., etc. New York 1855, vol. ii. pp. 18, 20.

4. An air loaded with putrid miasms or animal exhalations, as that of crowded hospitals, camps, ships, and transports; and —

5. The contact of animal matter or of diseased secretions or discharges, as in using unclean sponges, etc.

From what Dr. Copland has seen of the disease in foreign hospitals, he inferred that although the fourth and fifth of these are the most common exciting causes, the others are often more or less influential, either in predisposing to it or in directly producing it, especially after severe injuries and operations, or when aided by the depressing passions; and that the causes commonly giving rise to typhoid or putro-adynamic fever will often occasion it, especially in crowded surgical wards of hospitals.

A recent writer on military surgery, in noticing the hospital gangrene which appeared amongst the English troops in the Crimea, states that —

According to Dr. Macleod, the hospital gangrene of the Crimea was accompanied with fever, sometimes preceding, sometimes accompanying, sometimes following the local outbreak.

"The attendant fever was uncertain in its development; sometimes it preceded, sometimes it accompanied, and sometimes it followed the local outbreak. Often there was little if any constitutional disturbance, and occasionally the fever was of a low typhoid type. The most generous diet was always necessary; for though it may be true, as was the case in the Peninsula, that an antiphlogistic treatment is at times necessary, it can be so only in strong, healthy men, who derived the disease from infection. With us the depression of the powers of life was so marked, and appeared to exercise so strong an influence, as predisposing to its outbreak, that in place of lowering remedies, the most strengthening, including stimulants, and above all, fresh air, were absolutely required, and were alone of any use. Those who had suffered in camp from diarrhœa, and whose strength had thus been much reduced, more especially those whose constitutions were strongly impregnated with scurvy, were most liable to be attacked; and in all our cases, so far as I saw, the development of the disease resulted from a lowered general health more than from specific causes. It was, in many cases, a veritable 'child of the typhus.'" [1]

These examples are sufficient, we believe, to represent truly the views of the best writers, and at the same time to present impartially the question of the local or constitutional origin of the disease.

In its mode of origin, hospital gangrene may be viewed in four different ways: —

[1] *Notes on the Surgery of the War in the Crimea, with Remarks on the Treatment of Gunshot Wounds*, by George H. B. Macleod, M. D., etc.

1. *As a Local Disease, communicable only by Contact with Animal Matter in a Certain State of Change or Decomposition.* — Whatever constitutional disturbances arise, they are always consequent to and upon the changes in the wound itself, and arise chiefly from a propagation of the derangement by nervous sympathy. If this proposition be true, amputation would be one of the most certain methods of removing the disease.

Views of the author as to the mode of origin of hospital gangrene. The entire subject presented in four distinct propositions.

2. *As a Constitutional Disease.* — The constitutional disturbance manifesting itself in gangrenous inflammation in any wounded surface may be produced either by previous exposure and bad diet, or by the constant inhalation of an atmosphere deprived of its active oxygen and electrical fluid, and loaded with carbonic acid gas and sulphureted hydrogen, and other deleterious gases and animal matters. According to this view, when the constitution is deranged, the blood altered, and the forces depressed by such agencies, the disease may appear in any wounded surface apart from any direct application of poisonous animal matter.

3. *As both Local and Constitutional in its Origin.* — Animal matter, in a certain state of decomposition, is capable of acting upon a wounded surface and of developing gangrenous inflammation; or the system may be so depressed by the action of gases and foul air inhaled, and by previous exposure and diet, that this form of inflammation may result from the depression of the forces, the derangement of nutrition, and the consequent degeneration of wounded parts. If the disease arise locally, the absorption of the gangrenous matter commences as soon as it is applied to any wounded surface, and goes on continuously as long as any gangrene is present; and the decomposing matters entering the blood derange its composition and the nutrition of the body, and depress the forces. In this way the constitutional derangements may be manifested before the local changes are evident to the senses, without at all standing in the relation of cause and effect. The admission of its local and constitutional characters at the same time, is not at all contradicted by the fact that we may have in the same patient one gangrenous wound and another entirely free from the disease. Neither does it follow that because the absorbed matters disturb the nutrition and the composition of the blood, and derange to a certain extent the forces, therefore amputation will not arrest the disease. Whether or not the severing of the gangrenous mass from the body will arrest the disease, will depend not upon the mere fact of the absorption of the gangrenous

matter, but upon the extent to which it has deranged nutrition and depressed the forces. Thus, the poison of the rattlesnake produces death of the immediate parts into which it is injected, and at the same time that portion which is absorbed alters the blood, acts upon the heart, deranges the nutrition, disturbs the circulation and respiration, and depresses the nervous and muscular systems. If the limb poisoned and rendered gangrenous by the poison of the rattlesnake be amputated in the sound parts, it does not follow that because the constitution has been affected by the poison absorbed, that therefore the stump must also become gangrenous. Neither does it follow that because the gangrene was not reproduced in the stump, therefore the poison of the rattlesnake did not act constitutionally.

In the case of amputation for a gangrenous wound, the reappearance of gangrene in the wound will depend on the amount of the matter absorbed from the local source, and the extent to which it has deranged the system.

4. *The Disease may arise from the Action of a Specific Poison, which acts in a Manner similar to that of Small-pox, Measles, and Scarlet Fever.* — After the introduction of the poison, either through wounded surfaces or through the skin and lungs, certain constitutional changes are excited which precede the manifestation of the local symptoms, and are connected intimately with, if not in the relations of cause and effect with, the local manifestation. In other words, the specific cause of hospital gangrene may induce such changes in the constitution of the blood, and so modify the nutrition of the body, and so depress the forces, that however the poison may have been received by direct contact to the wound or through the atmosphere, all local inflammations may manifest its specific gangrenous action.

The third proposition expresses most nearly our views, for it is capable of demonstration.

First, That hospital gangrene may arise in those exposed to the exhalations from gangrenous wounds, without any abrasion of the surface. This will be illustrated by the following observations: —

Case I. Showing that hospital gangrene may arise in those exposed to the exhalations from gangrenous

Case I. Empire Hospital, Vineville, Ga.; George N. Tippin, Company H, 1st Florida Regiment. Native of the southern portion of Alabama, near the Florida line. Entered this hospital with what was said to be typhoid fever, on the 10th of September, 1864, and was treated in a tent containing several cases of hospital gangrene, and surrounded by other tents containing numerous cases of this disease. The attack of

fever, which had been of some standing before entering this hospital, was said to have been slight, and the patient was convalescent in the course of ten days. On the 28th, the patient complained of a painful swelling on the margin of the perinæum and left buttock. On the 31st, I examined the affected spot, and found the surface for the space of near one half an inch in diameter of a bluish, grayish color, as if the skin was dead. The lancet passed readily through the dead integuments and tissues, and a large quantity of dark, grumous, tar-like, gangrenous matter, of a most offensive smell, flowed out. The odor was so offensive that it was almost impossible for the attendants to remain in the tent. After the evacuation of the dark, fetid matter, the structures within presented the general appearance of hospital gangrene, and not of an ordinary abscess. The edges of the wound became inverted, and were surrounded by a purplish border in the skin, and the destruction of tissue progressed rapidly. The wound was freely cauterized with nitric acid, and the patient placed upon tincture muriate of iron and quinine, and nutritious diet. This treatment appeared to be productive of much good, and the gangrenous surface in the course of a week assumed a more healthy appearance, and in the course of ten days the gangrene appeared to be entirely removed. This patient was not, however, isolated by removal from the gangrene ward; and the disease reappeared, and advanced with increased power, and denuded a large portion of the muscular structures of the perinæum and left buttock. On the 6th of November, the gangrene was burrowing extensively around the anus, and exposing the muscles of the perinæum and the bulb of the urethra; the complexion was of a leaden hue; the expression of the countenance was distressed and haggard; nervous system irritated and weak; pulse feeble and rapid; appetite entirely gone; and the recovery of the patient doubtful.

wounds, without any abrasion of the surface.

Dr. Trotter, in his account of the malignant ulcer, — hospital gangrene, — has recorded similar observations: —

"Although for the most part these ulcers spring from some external injury, yet we have met with a number of cases where neither wound, puncture, scab, or contusion could be said to have first taken place. A small, circumscribed red spot would be first perceived, scarcely to be felt; but in a few hours rising to a pimple, becoming black in the centre, and inflamed round the edges, till it increased in size, swelled, and assumed every characteristic symptom, with concomitant fever, and subsequent ulceration, sloughs, and fetid discharge."[1]

Similar observations recorded by Dr. Thomas Trotter.

"Some cases we have also met with where no previous injury had been offered to even the cuticle, that could be suspected or discovered; these began on the fleshy part of the leg and fore-arm, and

[1] *Medicina Nautica*, vol. ii. p. 177.

were followed with the separation of nearly the whole integuments and muscular parts of the limb."[1]

These cases of Dr. Trotter occurred in the crowded and badly ventilated ships, lying idly in port.

We are justified by the preceding case, and by these observations of Dr. Trotter, in drawing the conclusion that the poison inducing hospital gangrene is capable of entering the system through the pulmonary and cutaneous systems, and of exciting gangrene in parts which were perhaps in a state of defective nutrition, degeneration, or inflammation, or of depressed vitality; but which, as far as known, were not exposed in any manner to the direct action of the poisonous matter, and over which the integuments were, until they were involved by the gangrene from within, in an unbroken and uninjured state.

Second, That hospital gangrene can be communicated through the atmosphere to wounded surfaces, without any direct application of the matter.

Thus, in the large numbers of wounded which, after the battle of Chickamauga, were crowded into the hospitals at Augusta, the disease appeared simultaneously in a large number of wounds which were, as far as the bandages, and utensils, and nurses were concerned, separated from each other. The common medium into which the effluvia from the wounds and the exhalations from the lungs, skin, and urinary and intestinal excretions were poured, was the atmosphere, and we are justified in concluding that through it the poison was transmitted.

The following interesting communication from Surgeon D. J. Roberts illustrates in a still stronger manner the possibility of the transmission of the poison of hospital gangrene to a large number of wounds entirely through the atmosphere. Many of these wounds, from the time of their reception to the appearance of the gangrene, had not even been dressed, and in many the original dressings after amputation had not been removed: the suspicion of the transmission of the poison from one to the other by contact, cannot therefore be entertained.

20TH TENNESSEE REGIMENT, TYLER'S BRIGADE,
BATES' DIVISION, ARMY OF TENNESSEE,
NEAR LOVEJOY STATION, GA., *September 8th*, 1864.

SURGEON JOSEPH JONES, C. S. A.,
AUGUSTA, GA.

Observations of Surgeon Roberts, C.

SIR, — I beg leave to make the following statement of cases of hospital gangrene that have come under my observation within the past few days.

[1] *Medicina Nautica*, p. 210.

About two hundred of our wounded were left at Jonesboro', Ga., on the 1st inst. They fell into the hands of the Federals, who deprived them of the greater portion of their attendants, and some of the surgeons left with them, — so I am informed.

S. A., upon the origin of hospital gangrene amongst the Confederate wounded after the battle of Jonesboro'.

The enemy having fallen back north of Jonesboro', they were sent for on the 7th inst. They were found collected together in two houses, never before used as hospitals. They had received very little medical or other attention — some none — since the first dressing of their wounds; very few if any of their wounds having been dressed or even washed since they had left the field hospitals. A large proportion of the wounds were amputations; the others, all severe cases. Nearly every case presented well-marked symptoms of hospital gangrene; some in an incipient stage, others more advanced, and some full and well developed cases.

The disease was produced, in my opinion, by want of cleanliness, and closely crowding together a large number of severely wounded in a small space.

These men were freshly wounded, just from the battle-field, and placed in a house that had never before been used as a hospital. There was, therefore, no opportunity of the disease being produced by contagion from previous cases.

I am, sir, most respectfully,
Your obedient servant,
DEERING J. ROBERTS,
Surgeon 20th Tennessee Regiment.

The transmission of the gangrenous poison through the atmosphere was still further illustrated by a case related to me by Surgeon E. N. Covey, Medical Inspector District of Virginia, Tennessee, and Georgia: —

CASE II. A medical officer, connected with one of the general hospitals of the Army of Tennessee, was attacked with sore throat whilst attending upon cases of hospital gangrene. His symptoms becoming alarming, a careful examination was made, and the throat was found to be affected with hospital gangrene.

Case II. Related by Surgeon E. N. Covey, C. S. A.

Third, In some cases, after the wounds have been subjected to the action of the cause of hospital gangrene, a certain period of time elapses before the disease appears.

The following case illustrates the truth of this proposition: —

CASE III. John Kemp, sergeant 11th Regiment Tennessee Vols. Age, twenty; height, six feet; brown hair; grayish-blue eyes; florid complexion in health; weight in health, one hundred and sixty

Case III. Illustrating the proposition that in some cases after the wounds have been subjected to the action of the cause of hospital gangrene, a certain period of time elapses before the disease appears.

pounds. Wounded 19th of September, 1863, at battle of Chickamauga, in right foot; minie-ball entered about two and a half inches below the external malleolus, and passing around the bones of the instep, or tarsus, made its exit at a similar distance from the internal malleolus. The bones of the tarsus do not appear to have been seriously injured. Remained at the field infirmary from the reception of the wound to the 24th of September, when he was sent to Atlanta, where he remained in general hospital until the 28th inst., when he was transferred to Augusta. Arrived at the car-shed in Augusta at six o'clock A. M., September 29th, and remained there until one o'clock, P. M., and was then received into the Catholic Church, second division, Third Georgia Hospital. After remaining in this crowded ward for several days, was transferred to the Presbyterian Church, where he remained, together with some three hundred other wounded soldiers, many of whom were suffering with gangrenous wounds, until October 15th.

At this date (October 15th), although he had been exposed to a foul atmosphere in these badly ventilated churches, crowded with wounded suffering with ill-conditioned and gangrenous wounds, his wound looked healthy, and appeared to be healing. From the fearful increase of gangrene, this patient was transferred to private quarters, in a house situated at the corner of Broad and Washington streets. The wound continued to improve, and was nearly healed up, when, on the 4th of November, near twenty days after his transfer from the infected atmosphere of the hospital, the wound felt very painful, as if thousands of needles were pricking the injured surface. The patient was unable to sleep during the succeeding night, and was feverish and restless. The wound commenced to swell, and the edges became ragged and everted, and the parts around assumed a red, inflamed appearance. Loss of appetite, nervous depression and irritation, and fever accompanied these symptoms. Nitrate of silver was applied freely to the diseased surface, which now commenced to emit a disagreeable, fetid odor. The application of the caustic relieved the pain to a considerable extent, but it did not check the progress of the disease. November 7th, the patient was transferred from private quarters back to the Catholic Church. At this time the external wound of entrance was healed. The wound at the point of exit of the ball was one inch in diameter, swollen and raised above the surrounding surface of the instep, with everted edges, and surrounded by an inflamed, purplish areola. Surface of the wound covered with a moist, gray, and brownish and greenish slough. Odor nauseous and putrid. Upon the recommendation of Dr. L. A. Dugas, Professor of Surgery in the Medical College of Georgia, nothing was applied to the diseased mass but common salt. Whiskey ℥iss, and tincture muriate of iron, m. xv., were administered three times a day.

November 8. — Gangrene extending. The salt which covered the wound caused much pain, and appeared to exert no beneficial effect. Pulse, 94 in the morning and 98 in the evening. Treatment continued.

November 9. — Gangrene continues to spread. Treatment continued.

November 10. — Five o'clock P. M. Pulse, 100 beats to minute. Temperature of hand, 85° F. Temperature under tongue, 102° F.

November 11.— Gangrene spreading. Eight o'clock A. M. Pulse, 98. Temperature under tongue, 100° F. Temperature of hand, 90° F. Treatment continued.

November 12. — Nine o'clock A. M. Hectic flush on cheek. Eyes present an excited, restless look. Complains of the pain in the wound, and manifests great nervous excitement whenever the limb is moved. Tongue pale, clear, and moist, and but slightly furred. Bowels regular, and have been so up to the present time. Skin warm, moist, and soft.

The wound is now about two inches in diameter, with ragged, everted edges. It resembles some forms of ulcerated, fungous cancer. The borders are elevated above the surrounding parts, whilst there is a depression in the centre. The surrounding skin presents a red and purplish inflamed border, about two inches in diameter, and the parts around are swollen. Yesterday a considerable slough separated from a portion of the gangrenous mass, and the parts beneath presented a more florid and natural color than the gray and greenish gangrenous structures; and from this portion of the ulcer a little pus now issues. Up to the time of the separation of this slough no pus has been visible. The muscles of the calf of the leg are swollen, and very tender and painful to the touch. The parts immediately around the gangrenous ulcer feel hotter than those at a little distance. These facts indicate that this form of gangrene resembles in a measure inflammation; but it is an imperfect form of inflammation.

Pulse, 100. Temperature of hand, 93.5°. Temperature under tongue, 100.5°.

Four and one half o'clock P. M. Pulse, 120. Temperature of hand, 103°. Temperature under tongue, 103.5°.

The actual cautery was applied to the wound, and the treatment with tincture muriate of iron and whiskey continued, together with nutritious diet.

November 13. — The marks of inflammation around the wound have increased, and this appears to be attributable to the effects of the actual cautery. Charcoal poultices are now applied to the wound.

Nine and one half o'clock A. M. Pulse, 102. Temperature of hand, 93.5°. Temperature under tongue, 102°. Bowels continue regular. Appetite still poor. Hectic flush of cheeks and the nervous irritability also continue.

Examination of Urine. — Amount of urine passed during twenty-four hours, from November 13, 4 P. M., to November 14, 4 P. M., grains, 23,496.79 (1,465 cubic centimetres).

Specific gravity, 1,018.5. Reaction strongly acid. Color of urine deep orange, with a decided tinge of red. Very slight deposit at the end of thirty-four hours.

ANALYSIS OF URINE, NO. 1.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours, November 13, 4 P. M., to November 14, 4 P. M.	23,496.79	
Urea	609.14	25.92
Uric acid	16.14	0.68
Free acid	23.68	1.007
Phosphoric acid	40.60	1.72
Equivalent of phosphorus in phosphoric acid	17.81	0.71
Sulphuric acid	37.68	1.13
Equivalent of sulphur in sulphuric acid	15.07	0.64
Chloride of sodium	130.85	5.56
Equivalent of chlorine in chloride of sodium	79.29	3.03

November 14. — A portion of the dead tissues in the wound have been thrown off. Concentrated solution of blue-stone (sulphate of copper) has been applied, and followed by charcoal poultices. Four o'clock P. M. Pulse, 120. Temperature of hand, 99° F. Temperature under tongue, 102° F. Hectic flush in cheeks, and nervous excitability continue. Urine, deep orange red.

November 15. — Ten and one half o'clock A. M. Pulse, 100. Temperature of hand, 85° F. Temperature under tongue, 99° F. Skin moist and soft. Bowels regular. Tongue clean. Appetite improving. The red border in the skin around the wound is paler than heretofore, and the swelling of the surrounding parts appears to be subsiding. The pain in the wound, as well as the general nervous excitability and depression, have also to a great extent disappeared. Treatment continued.

November 16. — The red color of the surface around the wound has disappeared. The swelling in the surrounding parts has in a great measure subsided, and the edges of the wound are not prominent and everted. All the dead tissues have come away or been removed by the knife and forceps, and the surface of the wound has a red and healthy look.

Eight and one half o'clock A. M. Temperature of hand, 92° F. Temperature under tongue, 100° F.

Five o'clock P. M. Temperature of hand, 96° F. Temperature under tongue, 99.5° F.

November 17. — Swelling has subsided. Wound is filled with granulations.

Nine and one half o'clock A. M. Pulse, 100. Temperature of hand, 98° F. Temperature under tongue, 100° F.

November 18. — The wound is now about two inches in diameter, and presents a florid, healthy look, with numerous granulations, and has lost the ragged and everted appearance of the edges. The skin adjacent to the ulcer presents a light purplish color.

November 27. — Up to this time the wound has continued to improve, and it is now not more than one inch in diameter. The peculiar color around the wound has daily grown paler, and now has nearly disappeared. Tongue clean and natural. Pulse, 92. Skin warm and soft. Bowels regular, and have been so throughout the entire case. The nervous excitability, irritation, and depression, have disappeared. The treatment has been continued up to the present time, with the exception of the discontinuance of the sulphate of copper, and the substitution of simple cerate for the charcoal poultice.

This case presents many points of interest which will be examined hereafter. We will notice at the present time only those results which bear upon the present inquiry. The wound continued to improve after this case was removed from the foul atmosphere of the hospital, and hospital gangrene did not appear for near twenty days after this patient had been exposed to the infection.

Baron Boyer has recorded a similar observation, and he affirms that it is certain that a patient who has received a germ of this disease in a hospital, cannot prevent it by any precaution whatever; and still further, that he has seen it appear among wounded men who fled from the epidemic to elevated situations, where the air was pure.

Dr. Taylor, in his report on the diseases of the 29th Regiment in the Crimean war, says: —

"It is to be observed, as illustrating the possibility of gangrene infection lying dormant for some days, or of a fomites of the disease hanging about the clothing of the men, that wounded men discharged fit to rejoin their regiments, were, in several instances, returned from camp to hospital with hospital gangrene."

It is also worthy of note, that during the period that our patient Kemp was exposed to the cause of the disease, and during the period that the poison appeared to be latent in his system, cases exposed to precisely the same infection were constantly arising. Whilst in this case twenty days elapsed between the exposure to the causes of hospital gangrene and the actual manifestation of the

disease, on the other hand, the wounds of the Confederate soldiers who fell into the hands of the Federals at Jonesboro' became gangrenous in the course of less than one week after their removal from the battle-field.

The following case, reported for me by Assistant-Surgeon F. A. Anderson, will show that under certain circumstances and under certain conditions of the constitution, particularly when the system has been depressed by disease and by the exhalations of the hospital and especially of gangrenous wounds, the direct contact of the gangrenous matter with a wounded surface may be followed by the development of the disease in the course of a very short period.

Case IV. When the system has been depressed by disease and by the exhalations of the hospital, and especially of gangrenous wounds, the direct contact of the gangrenous matter with a wounded surface may be followed by the development of the disease in the course of a very short period.

CASE IV. Ocmulgee Hospital, Macon, Ga. John W. Hollingsworth, 5th Georgia Reserves, Company B; age, twenty-two; previous occupation, farming. Was admitted into ward No. 7, October 30, 1864, with pneumonia, the disease involving only the right lung, and in the second stage. Expectoration free. Considerable blood in the sputa. Treatment, blister, ipecac, and opium. Patient improved rapidly until 5th of November, when symptoms of pneumonia appeared in left lung. A little hot toddy was administered, and the patient placed on pul. ipecac., grs. ii., pul. opii, grs. i., every four hours.

November 6. — Blister applied to right side. Patient improving.

On the evening of the 7th of November, the nurse, through mistake, applied, in dressing his blister, a cloth that had been used upon, or in dressing a phagedænic wound; and on the morning of the next day, November 8th, there were unmistakable symptoms of the disease having attacked the whole blistered surface. Offensive sanious discharge; the parts of a dark gray or purple color. The blistered surface was dressed with dilute nitric acid (f℥i. to ℥iv. water), which in a very short time corrected the disordered condition. Patient complained of no pain. Pulse, 130; respiration, 28 to 30, but easy.

Morning of the 9th of November, symptoms augur a speedy fatal termination. Abdomen and thorax tympanitic; dusky complexion; brilliancy of eyes; pulse, 140 to 150. Respiration rather slower, but apparently voluntary. Marked anxiety. He died about four o'clock P. M., 9th of November.

Post-mortem Examination, Six Hours after Death. — Upon opening the thorax, escape of gas, and a considerable quantity of serum. The anterior edges of both lungs almost normal. Small spots of extravasated blood. Upon removing the lungs and heart, for careful examination, the right lung was found to be in the third stage; the left in the second stage, or that of hepatization. The disease was very extensive,

involving all but the extreme anterior part of the lungs. The right lung appeared to be merging into the suppurative stage, and its condition was somewhat different from what is generally observed in this stage. A diffusive infiltration is very rare, the pus for the most part not being readily discovered because of its thorough sanious admixture; and this was the condition in this case. Upon the surface of both lungs, particularly of the lower lobes, there were numerous dark, softened spots. When immersed in water, the whole lungs sank.

At Andersonville hospital gangrene returned after amputation for the disease, and in recent wounds attacked the exposed surface within thirty-six hours.

Amongst the dejected, debilitated, diseased, and filthy Federal prisoners crowded into the foul prison and hospital at Andersonville, Ga., I observed that after amputation hospital gangrene almost invariably returned, if it had been before present, and, if the wound was a recent one, attacked the exposed surface in many cases within as short a period as thirty-six hours. The day before I arrived at Andersonville, in the month of September, 1864, a train of cars, conveying Federal prisoners to Charleston, South Carolina, ran off the track and was dashed against the side of a hill. The engine and several cars were completely wrecked, and a number of Federal prisoners were killed and wounded. I observed these wounded as well as other amputations and wounds in the Confederate military prison hospital at Andersonville, and noted the first appearance of the gangrene.

Case V. Rapid appearance and progress of hospital gangrene in Federal prisoners.

Case V. In the case of an amputation in the middle of the leg, from a compound comminuted fracture of the foot and leg received at the time of the railroad accident, the lips of the wound did not unite at all; and although the patient was a stout Irishman, and had never been in the hospital before this accident, and although he appeared to be in good health, in the course of twenty-four hours a blue line appeared along the edges of the flaps in the skin, which presented an inflamed and blistered appearance. The sutures came away (tore out), the edges of the wound gaped open, the stump assumed a grayish, and greenish, and bluish color, and in a few days the bones of the leg were denuded, and projected nearly two inches, so rapid had been the destruction of tissue. In another case, when the cap of the knee was simply cut to no great depth longitudinally, gangrene appeared in fifty hours, and progressed rapidly; and in another case of amputation, hospital gangrene appeared in twenty-four hours.

Period of the incubation of the poison

These observations tend to establish the fact that the period of incubation of the poison of hospital gangrene is not fixed, but varies with the condition of the system, with

of hospital gangrene not fixed.

the length of the period of exposure to the causes capable of producing the disease, and with the concentration and mode of introduction of the poison.

This proposition may be still further supported by the statements of various writers.

Thus, Mr. Blackadder affirms that when the morbific matter is inserted into a puncture or scratch, the first progress of this disease bears a resemblance to that of a part inoculated with vaccine matter.

Testimony of various writers as to the period of incubation of the poison.

According to this experienced writer, the primary inflammation in gangrenous phagedæna commences at the end of the second or early on the third day; the inflammation is at its height about the sixth. When the scab begins to form in one disease, phagedænic ulceration begins in the other, and, when allowed to proceed, soon affords sufficient proof of the non-identity of the two diseases. When the disease attacks a recent gunshot wound, remarks this observer, the discharge, two or three days after infection, is found to be lessened, and to have become more of a sanious than purulent nature. The sore has a certain dry and rigid appearance; its edges are more defined, somewhat elevated and sharpened; the patient is sensible of a change in the usual sensation in the sore, and complains of the occasional stinging sensation, resembling that produced by the sting of a gnat. At this period, but sometimes a day or two later, the integuments at the edge of the sore become inflamed, and the surface of the sore itself assumes a livid or purple color, and appears as if covered with a fine pellicle, such as is formed on a coagulum of blood.[1]

Boyer, who adopts the view of Pouteau and of many other writers, that hospital gangrene may be communicated to a wound or a simple ulcer of a person of the most healthy constitution, breathing the purest air, merely by the contact of linen or lint infected with the leaven of the disease, believes that this inoculation is the more to be dreaded, and is more speedy and certain in its effects, when patients have already been exposed to the action of causes capable of producing the disease, and whose constitutions favor its development.

Dr. Thomson admitted that the time at which the disease begins to show itself after the infection has been received, was not positively ascertained, and expressed the belief that he had repeatedly seen hospital gangrene attack patients in less than three days after they had been exposed to its influence.

[1] *On Phagedæna Gangrænosa*, p. 33.

The establishment of the facts that the poison of hospital gangrene has no definite period of incubation, and that it may arise *de novo* at any time, and that the disease may be communicated either through the atmosphere or by direct contact, is of importance in its bearings upon the classification of this disease.

The facts that hospital gangrene has no definite period of incubation, that it may arise *de novo* at any time, and that it may be communicated either through the atmosphere or by direct contact, of importance in their bearing upon the classification of this disease.

Thus, certain diseases, as syphilis and cow-pox, are communicated only by actual contact of infectious matter, while on the other hand, hospital gangrene, small-pox, measles, whooping-cough, scarlatina, and typhus and typhoid fever, are communicated not only by actual contact, but also by the transmission of an effluvium from the original source of infection through the medium of the air. Certain diseases, as syphilis, small-pox, and measles, are, as far as the knowledge of diseases extends, never spontaneously generated, but appear to be always propagated by animal matter, transmitted in succession from one person to another. On the other hand, typhoid fever, and hospital gangrene, and typhus fever, may, under certain circumstances, arise *de novo* without any previous exposure to infection.

Fourth, In some cases, poisonous matters are so rapidly absorbed from the infected atmosphere of the crowded wards, and the diseased action is propagated with such rapidity from the local injury to the central organs, in constitutions broken down by bad diet, exposure, and by the influence of the foul emanations from the wounded and sick crowded into badly ventilated hospitals, that death results from the effectual and almost immediate poisoning of the system, before the local disease has progressed to any extent.

Rapid poisoning of the system in hospital gangrene.

This proposition is well sustained by some observations recorded by Mr. Guthrie, in his "Treatise on Gunshot Wounds:" —

"I wish now to draw attention to a state of gunshot wound which I have not often seen, but which is highly dangerous, infinitely more so than those I have been noticing, in which the inflammatory stage runs on to the suppurative. It will, perhaps, be best explained by a case.

Observations of Mr. Guthrie, illustrating the rapid poisoning of the system in some cases of hospital gangrene.

"After the battle of Albuhera, Mr. Curby, Assistant-Surgeon of the 29th Regiment, drew my attention to the case of a man, as something peculiar, whom I had seen with him the day before, with a shot through the thigh, and who died after a short illness the following morning. In the evening he had complained of pain, which had increased so much on the last visit as to demand par-

ticular attention, and fomentations and an opiate were ordered. The pain, it was reported, continued during the night, and in the morning, early, he died. The body was carried away, and no examination was made.

"On the retreat of the army from Fuerte Guinaldo, in 1812, a smart affair took place at the Convent of Saca Farte, between the advance of the French and the cavalry and the fourth division of the British army, under Sir T. Cole, to which I belonged. The wounded accompanied me to Sabugal, on the heights near which we offered battle. Among them was a man, a stout, handsome soldier, who had been shot through the right thigh, the ball entering below the femoral artery, passing through and outwards close to the bone. This wound went on remarkably well for near a fortnight, so much so that the man had actually got up and walked about. I saw him at one o'clock, and, as he was standing, desired him to keep himself quiet; he answered, he felt quite well. In the evening, Mr. Mahoney, now Surgeon of the Fusileers, who occupied the same quarters with me, reported, that the man was suffering some pain, and that he had ordered him an opiate and a poultice. He died early in the morning, having complained a good deal in the night, but not sufficiently to induce the orderlies to call Mr. Mahoney, until symptoms of approaching death alarmed them. I examined the limb carefully, within twenty-four hours of the man's being in comparative health. On the day previous to his death, the wound looked favorably, there was little or no inflammation, the limb was soft, and he was capable of walking, and conceived himself comparatively well. Inflammation came on in the night, internally, deep, and hardly affecting the skin with redness; on dissection, the thigh appeared swelled, although not particularly so; but on cutting deeply through the fascia in the course of the wound, the whole thigh seemed so stuffed, or gorged with blood, that the texture of the parts, muscular as well as cellular, was soft, and readily giving way to a moderate pressure of the fingers; I can only compare it to the appearance of a part just falling into a state of gangrene.

"I lost a French prisoner precisely in the same way, after the battle of Salamanca; and Mr. Knight, late Inspector-General of the medical department of the army, informs me that at the Helder, in 1799, his attention was drawn to a case of the same nature, which terminated fatally; and, on dissection, the appearances gave him the idea of a part which had fallen, or was immediately about to fall, into a state of gangrene. It is not easy to say with precision, when a case of this description, which is so exceedingly rapid in its course, is cured, or rather prevented; I am almost certain I have lost others, and I think I have saved some. In either way, the cases are very rare. After the battle of Toulouse, where the strictest attention was paid to everything peculiar, there was not one. It would appear that this attack, which runs

so rapid a course, is one of inflammation of the most acute kind, tending to gangrene, and the means of relief must be proportionately active."[1]

Mr. Guthrie, in his observations upon erysipelatous inflammation, notices a form of disease which I think is closely allied to that just described, and the fatal termination, without any marks of extensive local injury, appears to be due to the rapid poisoning of the general system. The following are the observations of Mr. Guthrie: —

"There is an inflammation which I have seen several times occur in gunshot wounds, which I do not perfectly understand, and which, as it is attended by peculiar and fatal circumstances, deserves particular attention. It is not common, seldom more than one or two cases occur in a hospital of a thousand men, and they generally take place after the first ten days. My attention was first drawn to it after the battle of Albuhera, in consequence of losing three men very suddenly, whose death I did not expect, having seen them in the evening; and in all the three cases, on finding their places vacant in the morning, was informed on inquiry, that they had died during the night, and had been carried away. The death of the first did not attract my attention; that of the second left an impression which made me attend more particularly to the third, and to consider the affection as something peculiar. Two cases occurred after the battle of Salamanca, and one at Toulouse. I did not see a case among the wounded at the sieges of Ciudad Rodrigo, Badajos, or Burgos; the wounded at the battles of the Pyrenees only came under my direction at a period later than I have known it occur; neither did I see one at Brussels or at Antwerp, after the battle of Waterloo. It is very possible some may have occurred which escaped my observation.

"This inflammation makes its appearance after the first ten days in every case; and in all that I have seen, the injury was in the upper extremity. The wound, from being only a simple one without fracture, begins to swell and to become painful, and the swelling increases. The redness, which is of a pale color, more resembles the phlegmonous than the erysipelatous inflammation, whilst the skin has a shining, glossy appearance, and the tumefied parts retain, in slight degree, the impression of the finger, although the accomplishment of it gives great pain, and to a certain extent is resisted by the firmness of the parts below. The pain is not greater than in other cases of inflammation, and is rather burning than throbbing. The constitution sympathizes at first only in a moderate degree. The swelling and shining appearance continue to extend up to the axilla. The patient can sit up and wash his own arm (in two instances they walked about), and neither his coun-

[1] *Treatise on Gunshot Wounds*, third edition. London, 1827, pp. 96, 97.

tenance nor pulse indicates the near approach of dissolution, which in five or six cases took place a few hours after the last visit, when the appearances were such as I have described. In the five fatal cases, I could only learn that they got worse during the night, that is, the pain increased, difficulty of breathing came on, and death. In all, this took place the day after the swelling had reached the axilla; and in the fifth case, the result appeared to me so certain at the same period of time, that I desired the orderly to take care that if the man died during the night, he should not be removed. This direction seemed to surprise the orderly, who had no suspicion that the man would die; but his first salutation at half past five in the morning, when I came into the hospital, was, 'Sure, sir, the man is dead.' I relate the case in this manner to draw the attention more strongly to the impression it had made on my mind, that the complaint may not be overlooked on future opportunities offering themselves, and that it may not too hastily be considered as a common case of erysipelatous or œdematous inflammation. The three first cases were not examined after death. In the fourth, I could discover nothing particular beyond inflammation of the veins, especially those leading to the axilla, the axillary vein being also inflamed, to which I attributed the man's death, without considering it very peculiar, being of frequent occurrence in fatal cases after amputation. In the fifth, the man died of effusion into the chest on the same side as the injury of the arm, the whole of which was much enlarged, and had been highly inflamed; but the great veins were not affected as in the former instance.

"The sixth case occurred after the battle of Toulouse, in the Caserne de Calveti hospital, under the direction of Staff-Surgeon Bontflower, and in the immediate charge of Mr. Franklyn, now Surgeon of the 37th Regiment, to whom I pointed it out at its commencement as of very dangerous tendency; and it was from that moment an object of particular attention. The man was bled, purged, vomited, and diaphoretic remedies were administered, composed of calomel, antimony, and principally opium. Poultices were applied to the wound, and cold applications to the remainder of the limb. The arm swelled nearly up to the axilla, and I fully expected it would have taken the same course as the others, but it did not do so; the inflammation gradually subsided; the arm diminished, and resumed its usual appearance; the exact time I cannot mention, having lost the particulars of the case. During this process the man's health declined, he suffered an attack of fever, became afterwards jaundiced, and died under symptoms of diseased liver. There was nothing wrong at his death about the arm which had been inflamed.

"It is from the termination that I have been induced to give the caution not to mistake the disease for a common case of unhealthy or diffused cellular inflammation; and even admitting that it should be

hereafter proved to be so, there will still be something very peculiar in it, and deserving investigation. I am disposed to hazard a conjecture, that it was effusion in the chest which carried off the first three patients; that the inflammation of the veins of the arm in the fourth was an accidental occurrence, although of this I am by no means positive. The treatment to be adopted should be that which was made use of in the last case, and which proved successful in removing the inflammation, although the patient subsequently died from fever and visceral disease." [1]

Macleod, in his "Notes on the Surgery of the War in the Crimea," has recorded the following interesting observations on a most rapid and fatal form of gangrene: —

Observations of Macleod on a rapid and fatal form of hospital gangrene.

"In the Crimea, during the heat of the summer of 1855, after the taking of the Quarries, and the assault on the great Redan in June, not a few amputations of the thigh were lost, from moist gangrene of a most rapid and fatal form. In the case of a few who lived long enough for the full development of the disease, gangrene in its most marked features became established; but most of the men expired previous to any sphacelus of the part, overwhelmed by the violent poison which seemed to pervade and destroy the whole economy. This form of the disease occurred in four cases under my own charge, in men who had had a limb utterly destroyed by round-shot or grape. In all, the knee joints were crushed, the collapse was deep and prolonged, and the operation performed primarily in the middle third of the thigh. Three of the four were of very intemperate habits. All these cases took place about the same time, at midsummer, when many other similar cases occurred in camp. The wards, though full, were not overcrowded, and could not from their construction be freely ventilated. The weather was sultry, and cholera was in the camp. The atmosphere was surcharged with electricity, and the dreaded sirocco prevailed. Wounds generally assumed an unhealthy aspect for days, when this pestilential wind blew. The cases of all those who died in my wards seemed to be doing perfectly well up to sixteen hours, at the furthest, before death. Three of them were seized on the eighth day after amputation, just as suppuration was being established. The fourth died in the fifth day. The seizure and consequent symptoms were indicated in them all. In recording one case, I relate all.

"During the night previous to death, the patient was restless, but did not complain of any particular uneasiness. At the morning visit, the expression seemed unaccountably anxious, and the pulse was slightly raised. The skin was moist, and the tongue clean. By this time, the

[1] *Gunshot Wounds*, pp. 111-114.

stump felt, as the patient expressed it, heavy like lead, and a burning, stinging pain had begun to shoot through it. On removing the dressings, the stump was found slightly swollen and hard, and the discharge had become thin, gleety, colored with blood, and having masses of matter like gruel occasionally mixed with it. A few hours afterwards the limb would be greatly swollen, the skin tense and moist, and marked along its surface by prominent blue veins. The cut edges of the stump looked like pork. Acute pain was felt. The constitution by this time had begun to sympathize. A cold sweat covered the body; the stomach was irritable, and the pulse weak and frequent. The respiration became short and hurried, giving evidence of great oppression, of which the patient so much complained. The heart's action gradually and surely got weaker, till, from fourteen to sixteen hours from the first bad symptom, death relieved his sufferings. All local and constitutional remedies which could be thought of were equally powerless; nothing could relieve the system from the weight which seemed to crush it, or enable it to support the severe burden. Strong stimulants were the only remedies which appeared to retard the issue for a moment. Post-mortem examination, instituted shortly after death, showed the tissues of the limbs, and in many cases those of the internal organs also, to be filled with gas and loaded with serous fluid. The vessels leading from the stump were healthy, and in only one case had there been any actual mortification previous to death. The intestines, in two of the four cases, were much diseased.

"Was the cause which gave rise to this affection referable to 'weakness or defective powers of action,' arising from the patient's bad state of general health, or excessive irritability or disposition to act, from their being of intemperate habits? or was it excessive irritation or excitement to act, arising from the severity of the injury sustained? After the taking of the city in September, the same form of disease again appeared, especially among the Russians who had been operated on, and was so deadly that in no case which I could hear of did recovery follow."[1]

APPEARANCE AND CHARACTERS OF THE LOCAL CHANGES.

Appearance and characters of the local changes. Severe pains in the inception of the disease.

In many cases of gunshot wounds which subsequently became gangrenous, the attention of the wounded men was first called to the injured parts by severe and darting pains in the wounds. These pains were sometimes compared by the Confederate soldiers to the pricking of thousands of needles. In other cases the early stages of the disease were announced by a stinging or itching sensation; whilst in

[1] *Notes on the Surgery of the War in the Crimea, with Remarks on the Treatment of Gunshot Wounds*, by George H. B. Macleod.

some cases there was little or no change in the sensation of the part.

In some cases, in the earliest stages the wounds presented a dark-red glazed surface; the granulations became altered in appearance, and rapidly disappeared; the discharge of healthy pus disappeared, and was followed by a reddish and greenish sanious fetid discharge. The parts around the wound became painful and swollen, and frequently a well-defined red and purplish indurated border in the sound skin surrounded the wound. The wound itself rapidly assumed a swollen, ragged appearance (the gangrenous matter often rising several lines above the surrounding tissues), with swollen, ragged, everted edges. With this infiltration of the diseased structures, and the consequent elevation of the surface and eversion of the edges of the wound, the glazed, dark-red appearance of the wound disappears, and the gangrenous mass presents a greenish and grayish color.

Early changes in the wound.

When the wounds were extensive, the gangrene would frequently appear in one or more circumscribed spots, of a dark gray and greenish color, and gradually spread over the entire surface, and destroy the surrounding tissues. I have seen extensive ulcerated surfaces in which the gangrenous parts remained almost stationary, whilst the surrounding portions of the wound presented a bright florid appearance. Case XLV. affords a good illustration of this appearance of a gangrenous mass in the midst of a large florid wound.

In extensive wounds the gangrene would frequently appear in circumscribed spots.

In cases of amputation in patients whose systems were depressed and deranged by bad food and foul air, as the Federal prisoners in the filthy and crowded military prison hospital at Andersonville, Georgia, hospital gangrene frequently made its appearance in the wounds in from twenty-four to seventy-two hours; and in such instances the first symptoms of the disease were manifested in the absence of any adhesive effusion or inflammation, the swelling of the flaps, the rapid tearing out of the sutures, and the appearance of a deep blue and purplish discoloration of the skin around the edges of the wound. We have before described the first symptoms of the disease, in the case of the Irishman (Case V.) whose leg was amputated in consequence of a compound comminuted fracture received in a railroad accident near Andersonville.

In debilitated systems the first symptoms of hospital gangrene were manifested in the absence of any adhesive effusion.

Case VI. In another case in which the leg was amputated at the upper third, on account of the extensive ravages of a gangrenous wound, following a slight injury of the foot by a splinter, gangrene appeared in

twenty-four hours; and at the end of forty hours the stump presented a deep blue and purplish mottled appearance beyond the knee joint, and the constitutional symptoms were of the gravest character.

Marked congestion around the gangrenous wounds. Beneficial effects of hemorrhage.

During the active stages of hospital gangrene, the surrounding parts are swollen and infiltrated with serum, and the temperature of the parts immediately around the diseased structures is elevated somewhat above that of the parts beyond. As far as my observations extend, the serous fluid infiltrating the tissues is liquor sanguinis, and is capable of coagulation. The blood-vessels surrounding a gangrenous wound are always engorged with blood, as if the capillaries had lost their power to contract; and if an incision be made around the wound in the unbroken skin, these distended vessels bleed freely. I have noticed in several cases of severe gangrene, that after serious hemorrhage the recovery of the patient was very rapid, as if the emptying of the surrounding engorged vessels had contributed to the rapid improvement of the wound. The deep purple and blue color of the skin surrounding gangrenous wounds which are spreading rapidly appears to be due to the want of oxygenation in the blood, and also to the fact that this blood is altered and contaminated, and in fact poisoned by the neighboring gangrenous matter. The deep blue and purple color in the surrounding skin is one of the most infallible signs of the active progress of the disease. After the disappearance of the gangrene, the blue and purple border either disappears entirely or else fades away.

The following cases will still further illustrate this subject: —

Case VII. Illustrating the symptoms and appearance of hospital gangrene. Case of inoculation. Effects of foul atmosphere in producing the disease.

Case VII. Empire Hospital, Vineville, Ga. W. J. Black, Company G, Lee's Invalid Battalion; age, forty-six. Native of Troup County, Ga. Farmer by occupation. Height, five feet nine inches; weight in health, one hundred and sixty pounds; black hair and eyes; florid complexion. Has been in Confederate service three years and three months. Served two years with Stonewall Jackson. Was wounded about one year ago in Maryland; lost the first joint of the second finger; and has not been in field service since. Relieved from active service in the field by a board of physicians, on account of feeble health, and what was supposed to be an affection of the kidneys. The patient says that he often suffers with pain in his back, in the region of his kidneys. Acted as a nurse in Atlanta, at the Empire Hospital, and moved with it to Vineville, near Macon, Ga. Has been acting as a nurse in this hospital for the past two months, since the conversion of this institution into a gangrene hospital. During this time has been inoculated with

hospital gangrene twice. The first attack was caused by the prick of a pin on the side of the hand, received in dressing a gangrenous wound. The prick of the pin became painful almost immediately; and in the course of two days the injury commenced to inflame, and the surface around assumed a purplish and bluish color. The disease spread from the centre of infection, and the slough presented a grayish and greenish color. The inflamed and gangrenous parts were freely cauterized with strong nitric acid. By this means the gangrene was arrested before the ulcer had exceeded one quarter of an inch in diameter. This occurred in the beginning of September, about one month ago. The constitution did not appear to suffer, and the wound healed readily, and the patient resumed his labors as a nurse to the gangrene patients.

Had not been engaged in dressing the gangrenous wounds more than two or three days before a small blister appeared upon the third finger of his right hand, which gave much pain, and, in the language of the patient, "throbbed as if a bone was breaking loose." The blistered surface assumed a gray and greenish color, and was surrounded with a purplish and blue halo in the skin. The gangrene commenced to spread rapidly. Concentrated nitric acid was immediately applied three times a day, but it did not arrest the gangrene.

It appears that in the first inoculation, the system was not specially involved, and the local treatment arrested the disease.

But the continued residence in this infected atmosphere, and the constant attention upon the gangrenous wounds, gradually poisoned the system of this faithful nurse to such an extent that in the second attack the local treatment did not arrest the disease.

In this view, this case presents points of great interest in their bearings upon the history of the disease.

On the 3d of October, 1864, just twelve days after the commencement of this second attack of hospital gangrene, I executed the accompanying drawing.

The gangrene is progressing along the upper border under the blue discolored skin of the third finger of the right hand. The color of the skin in this portion of the wound, where the gangrene is progressing most rapidly, was of a most remarkable deep-blue. The lower portion of the ulcer appears to be improving somewhat, and now discharges a little pus.

The constitutional disturbances, notwithstanding the comparatively small surface involved, are well marked. Pulse accelerated, and feebler than in health. Face flushed. During the execution of the sketch of his right hand, suffered much pain from the confined position of the hand; was very restless and nervous, and was very much nauseated, and attempted several times to vomit. Hands tremble from the nervous irritation. No appetite. Tongue of a purplish, bluish, leaden color.

Has fever in the evenings, which declines towards the morning. Feels weak, nervous, feverish, and depressed.

On the 5th of October, when the appearance of the wound, as well as the general symptoms, were very much the same, I instituted the following analysis of the urine of this patient: —

Amount of urine collected during twenty-four hours, October 4, 5 o'clock, P. M., to October 5, 5 o'clock, P. M., 490 cubic centimetres = grains 7915.6.

Specific gravity, 1,028. Deep-brown, inclining to blackish-red color.

ANALYSIS OF URINE, NO. 2.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	7,915.60	
Urea	369.75	46.71
Uric acid	5.88	0.74
Free acid	26.41	3.33
Phosphoric acid	33.20	4.17
Equivalent of phosphorus in phosphoric acid . . .	14.57	1.84
Sulphuric acid	29.30	3.70
Equivalent of sulphur in sulphuric acid	11.72	1.48
Chloride of sodium	7.54	0.95
Equivalent of chlorine in chloride of sodium . . .	4.56	0.57

The following is the treatment adopted in this case, which is recorded here simply in its relations to the analysis of the urine:

October 1. — Tincture muriate of iron, gtts. xv.; sulphate of quinia, grains v., three times a day.

October 4. — Treatment continued.

October 5. — Treatment continued.

On the 7th of October, it was decided to furlough this patient, although his finger was still in a gangrenous condition. It was believed that his recovery would be very tedious, if not doubtful, in this poisoned atmosphere.

Case VIII. Hospital gangrene.

CASE VIII. Empire Hospital, Vineville, Ga. Thomas Paine, private, Company B, 1st and 4th Missouri Regiments, Stewart's corps; native of Bates County, Missouri. Occupation previous to entering the army, farming. Has been in Confederate service near four years. Age, twenty-two; height, five feet ten inches; weight in health, one hundred and fifty pounds. Brown hair; grayish-black eyes; fair freckled complexion. Has been generally healthy, and has had no sickness except the measles, since entering service. Has never been wounded before. Was wounded on the 17th of August, 1864, at Atlanta, Ga. A piece of lead, weighing about one pound, from a rifle shell, struck the middle of the left thigh, upon the external surface, and

lacerated the parts, but did not fracture the bone. Was taken to one of the brigade hospitals in Atlanta, where he remained five days, and was then transferred to the Ocmulgee Hospital. From the account of this patient, it appears that gangrene attacked his wound four days after entering the Ocmulgee Hospital in Macon. On the 27th of August, says that he experienced no special pain in the wound when the gangrene appeared.

Entered the Empire Hospital on the 2d of September. His attendant physician, Assistant-Surgeon V. T. Perry, who assisted me in the determination of the temperature in this case, informed me that up to the time of my examination, the general treatment consisted of stimulants, tincture muriate of iron, and opiates when necessary; and the local, of the daily application of strong nitric acid, the wound being afterwards dressed with lint or cotton saturated with turpentine or tincture of iodine. The actual cautery was upon one occasion substituted for the nitric acid. Under this treatment no amendment has been observable.

September 30. — Wound in the thigh about eight inches in diameter, nearly circular, and deeply and irregularly excavated; edges everted, and the surface coated with a dirty grayish, purplish, and dark bluish leaden color. No healthy pus was discernible, but in its stead the wound discharged a most fetid, irritating, sanious fluid. Tongue clean, red, and dry. Pulse, 120, quick and feeble. Respiration, 20. Temperature at three o'clock P. M., in hand, 40.9° C. (105.6° F.); in axilla, 41.1° C. (106° F.). Skin hot and dry; bowels constipated; urine scant and high colored.

October 1. — Eight and one half o'clock A. M. Pulse rapid and feeble, 105. Respiration, 16. Temperature of axilla, 39.2° C. (102.6° F.). Temperature of hand, 38.8° C. (101.8° F.). Skin moist. Bowels constipated; urine high colored. Wound of a dark greenish, gray and bluish color. The large muscles of the thigh are exposed by the gangrenous excavation, and they frequently can be observed quivering, especially after the application of nitric acid, which causes intense pain. Patient nervous and restless. Hands tremble, and the eyes present a nervous, restless, distressed expression. Whenever the patient sleeps, appears to be disturbed by visions, and talks constantly, and sometimes calls out aloud. Treatment continued.

Eight o'clock P. M. Pulse, 134. Respiration, 21.

October 2. — Eight o'clock A. M. Tongue clean, moist, and red. Pulse, 116. Respiration, 22. Temperature of axilla, 38.2° C. (100.7° F.). Temperature of hand, 29.5° C. (85.1° F.). Skin of extremities feels cool, soft, and moist. Bowels moved once through the night; the fœcal matters were said to be natural in color and consistence.

The drawing, Plate No. 2, was executed by myself on this day, and presents a general idea of the appearance and extent of the wound.

Examination of Urine. — Amount of urine collected during the past twenty-four hours, 1,500 CC. = grains 23,891.

Specific gravity, 1011.5. Bright red color.

Strong effervescence in the urine, upon the addition of concentrated nitric acid. At the end of forty-eight hours, the urine gave an alkaline reaction, and let fall a heavy light-yellow deposit of triple phosphate, oxalate of lime (dumb-bell and octahedral crystals), globular and acicular crystals of the urates of soda and ammonia, mucous corpuscles and vegetable cells.

ANALYSIS OF URINE, NO. 3.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	23,891.63	
Urea	635.25	26.58
Uric acic	3.00	0.125
Free acid	24.25	1.01
Phosphoric acid	50.82	2.12
Equivalent of phosphorus in phosphoric acid . . .	22.30	0.93
Sulphuric acid	32.72	1.302
Equivalent of sulphur in sulphuric acid	13.08	0 58
Chloride of sodium	110.88	4.64
Equivalent of chlorine in chloride of sodium . . .	73.15	3.06

Eight o'clock P. M. Tongue dry and red. Pulse, 114. Respiration, 22. Temperature of axilla, 40° C. (104° F.). Temperature of hand, 39.7° C. (103.5° F.). Two operations of bowels during the day.

October 3. — Eight o'clock A. M. Tongue clean, dry, and red. Pulse, 106. Respiration, 24. Temperature of axilla, 38.2° C. (100.8° F.). Temperature of hand, 34° C. (94.3° F.). Bowels moved once during the night.

Eight o'clock P. M. Tongue clean, red, and moist. Pulse, 101. Respiration, 17. Temperature of axilla, 38.2° C. (100.8° F.). Temperature of hand, 38° C. (100.4° F.).

October 4. — Condition of patient the same, except that bowels are loose.

Examination of Urine. — Reaction alkaline at the end of forty-eight hours. Heavy yellow deposit, consisting of triple phosphates (prismatic crystals), dumb-bell and octahedral crystals of oxalate of lime, granular and acicular crystals of the urates of ammonia and soda, and numerous vegetable cells.

Amount of urine collected during the past twenty-four hours, 650 CC. = grains 10,322.4. The bowels of this patient have been running off, and a portion of the urine has been lost. Deep orange color. Heavy light deposit and alkaline reaction at the end of the collection of the urine passed during the preceding twenty-four hours. Patient

complains of pain and difficulty in passing his urine. Specific gravity, 1,012.

ANALYSIS OF URINE, NO. 4.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	10,322.40	
Urea	210.21	20.36
Uric acid	1.30	0.12
Free acid	alkaline	alkaline
Phosphoric acid	6.00	0.58
Equivalent of phosphorus in phosphoric acid	2.62	0.25
Sulphuric acid	8.47	0.82
Equivalent of sulphur in sulphuric acid	3.38	0.32
Chloride of sodium	40.04	3.86
Equivalent of chlorine in chloride of sodium	26.42	2.55

October 5. — Eight o'clock A. M. Tongue moist and red. Pulse, 112. Respiration, 26. Temperature of axilla, 40° C. (104° F.). Temperature of hand, 39° C. (102.2° F.).

Eight o'clock P. M. Pulse, 104. Respiration, 20. Temperature of axilla, 39° C. (102.2° F.). Temperature of hand, 37.3° C. (99.2° F.). Bowels unmoved through the day.

Examination of Urine. — Amount of urine collected during twenty-four hours, October 4, 8 P. M., to October 5, 8 P. M., = 850 CC. Specific gravity, 1,015. Bright reddish orange color.

Heavy light-yellow deposit, ammoniacal odor, and alkaline reaction at end of twenty-four hours.

ANALYSIS OF URINE, NO. 5.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	13,601.00	
Urea	347.65	25.56
Uric acid	4.25	0.31
Free acid	alkaline	alkaline
Phosphoric acid	18.32	1.34
Equivalent of phosphorus in phosphoric acid	8.03	0.59
Sulphuric acid	8.47	0.62
Equivalent of sulphur in sulphuric acid	3.38	0.24
Chloride of sodium	19.63	1.44
Equivalent of chlorine in chloride of sodium	12.95	0.95

October 6. — Eight o'clock A. M. Tongue clean, dry, and red. Pulse, 112. Respiration, 24. Temperature of axilla, 38.6° C. (101.5° F.). Temperature of hand, 34.5° C. (94.1° F.).

Eight o'clock P. M. Pulse, 126. Respiration, 21. Temperature of axilla, 40.4° C. (104.8° F.). Temperature of hand, 40.2° C. (104.4° F.). Two operations from bowels during the day, which were said to be natural in consistence and color. Up to this date, the appearance of the wound remains unchanged, notwithstanding the daily application of nitric acid. The wound has not, however, spread to any great extent.

October 7. — Condition of the patient the same.

October 8. — Eight o'clock P. M. Pulse, 164. Respiration, 20. Tongue pale and moist. Bowels moved once during the preceding night.

Eight o'clock P. M. Pulse, 124. Respiration, 20. Bowels moved once during the day. Operation natural.

October 10. — Eight A. M. Pulse, 130. Respiration, 20.
Eight P. M. Pulse, 122.

October 11. — Eight A. M. Pulse, 124. Eight P. M. Pulse, 122.

October 12. — Eight A. M. Pulse, 132. Eight P. M. Pulse, 116.

October 13. — Eight A. M. Pulse, 116. Eight P. M. Pulse, 124.

October 14. — Eight P. M. Pulse, 136.

October 15. — Eight A. M. Pulse, 128.

October 16. — Eight A. M. Pulse, 128.

October 17. — Eight A. M. Pulse, 102.

The appearance of the wound was almost uniform until the 11th of October, when it gradually assumed a healthy appearance. In the course of six days from the 11th, all traces of gangrene left the wound. The use of nitric acid was abandoned on the 9th, by Assistant-Surgeon Perry, not because any amendment was observed, but for the reason that it appeared to accomplish but little good. Instead of the acid, the attendant physician substituted a cerate of the following constitution: Resin cerate lb. ½; oil of turpentine, ℥iii; tincture of iodine, ℥iss.

The bowels of this patient have generally been in good order, and the only medicine administered for their regulation was one small dose of castor-oil. Up to the present time, the appetite of this patient has been generally pretty good.

October 18. — Eleven o'clock A. M. Patient doing well. Appetite good. He is still, however, nervous and excitable, and easily disturbed. When I first entered the ward, his pulse was 120, and in a few moments it fell to 116. The surface of the wound presents a bright red color, and is covered with granulations and secretes pus.

Examination of Urine. — Amount of urine passed during twenty-four hours, from October 17, 11 A. M., to October 18, 11 A. M., 1,725 CC. = grains 27,479.4. Specific gravity, 1,014. Light orange color.

At the end of seventy-two hours, the urine was turbid, with a heavy white deposit of granular urates, prismatic crystals of the phosphates, and octahedral crystals of oxalate of lime. Reaction at the end of seventy-two hours alkaline.

ANALYSIS OF URINE, NO. 6.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during twenty-four hours	27,479.40	
Urea	664.12	24.31
Uric acid	8.28	0.301
Free acid	13.28	0.48
Phosphoric acid	19.12	0.69
Equivalent of phosphorus in phosphoric acid	8.39	0.305
Sulphuric acid	27.21	0.99
Equivalent of sulphur in sulphuric acid	10.88	0.39
Chloride of sodium	172.67	6.28
Equivalent of chlorine in chloride of sodium	104.63	3.86

October 19.— Patient continues to improve. Appetite good. Bowels regular. Wound clean, and bright red, with healthy granulations.

Examination of Urine.— Amount of urine passed during the past twenty-four hours, 890 CC. = grains 14,353.24. Specific gravity, 1,024.5. With the diminution in the amount of urine, the specific gravity has increased. The weather is cool, with light frosts in the mornings.

After standing over the cool night, the urine threw down a very light deposit. Light orange color. Carefully tested, together with a number of other specimens of urine collected from patients in various stages of hospital gangrene, for grape sugar; neither in this nor in any of the other specimens was any trace of the substance found. At the end of forty-eight hours the urine was still slightly acid, and a light yellow, almost white deposit had fallen. Under the microscope this deposit was found to consist of innumerable crystals of oxalate of lime, chiefly of the octahedral variety, granular and crystalline phosphates and urates, and round, irregular, orange colored masses.

ANALYSIS OF URINE, NO. 7.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during twenty-four hours	14,353.24	
Urea	438.59	30.35
Uric acid	10.14	0 70
Free acid (twenty-two hours after collection of urine)	17.28	1.20
Phosphoric acid	22.47	1.56
Equivalent of phosphorus in phosphoric acid	9.86	0.61
Sulphuric acid	28.20	1.97
Equivalent of sulphur in sulphuric acid	11.28	0.78
Chloride of sodium	61.67	4.29
Equivalent of chlorine in chloride of sodium	37.37	2.63

October 21. — Wound still improving. Presents a bright red, granulating surface, and discharges healthy pus. The gangrene dissected the muscles, and separated entirely the cellular tissue. Upon this day I executed the sketch, Plate No. 4; which gives a general idea of the appearance and size of the wound. By a comparison with the drawing of the wound during the state of gangrene, it will be seen that the parts surrounding the wound have greatly diminished in size. With the disappearance of the gangrene, and the improvement of the wound, the swelling and effusion have also disappeared.

October 22. — Ten o'clock A. M. Pulse, 104. Temperature of axilla, 38.2° C. (100.8° F.). Appetite good. Bowels regular. Tongue clean. Spirits of the patient excellent.

Eight o'clock P. M. Temperature of axilla, 38.2° C. (100.8° F.). Temperature of hand 37.4° C. (99.3° F.).

Temperature returns to the normal standard as soon as the wound assumes a healthy appearance.

We observe, amongst many other interesting points illustrated in this case, that the temperature returns to the normal standard, and the diurnal variations cease, as soon as the wound assumes a healthy appearance; the urine also returns to the normal standard, and loses its high color.

It is worthy of note, that when the temperature and the excretions returned to the normal standard, the wound was as extensive as during the active progress of the gangrene, when the constitutional symptoms were most marked, and the perturbations in the temperature greatest. And notwithstanding the nervous sensibility of the wound was as great if not greater after the removal of the gangrene, still the constitutional symptoms disappeared almost entirely.

It is fair to conclude that the derangement of nutrition, secretion, and excretion, and the depression of the nervous and muscular forces, and the perturbations of temperature during the active stages of the disease, arose in great measure, if not wholly, from the absorption of the poisonous matter causing the gangrene, and of the various altered products resulting from the decay of the tissues.

When the system has been thoroughly poisoned by the absorption of the gangrenous matter, various portions of the system removed from the

When the system has been thoroughly poisoned by the absorption of the gangrenous matter from a large wound, and by the constant inhalation of the foul atmosphere of the crowded ward, I have in a number of instances observed parts removed from the immediate wound, but generally upon the same limb, take on the gangrenous inflammation, and that too without any apparent cause, such as pressure.

wound may take on gangrenous inflammation.

Character of the gangrene thus arising.

In such cases, a purple or blue spot is first perceived, or the color might more properly be termed in some cases an ash gray or leaden hue. The cuticle is sometimes raised, and contains serum below. The rapidity of the progress of the gangrene in such spots will depend chiefly upon the extent to which the system has been poisoned by the absorption of the deleterious matters. I have seen the skin in the affected spot melt away in twenty-four hours into a grayish and greenish slough, whilst a deep blue and purple, almost black areola, surrounding the dead mass, spread rapidly in ever increasing circles; whilst the skin and tissues within, over which it had just passed, changed rapidly to the ash gray, and green and bluish hue characteristic of this form of gangrene. This is witnessed most generally in the worst and fatal cases.

In some cases the gangrenous slough presents a black, hard crust, which can only be removed by poultices. As long as the crust remains, the case progresses unfavorably; and in fact, as far as my experience extends, these are amongst the most inveterate and obstinate cases.

Relative rapidity with which gangrene destroys the different tissues.

Hospital gangrene destroys the cellular and adipose tissues most rapidly; the muscles, nerves, large blood-vessels, and the bones, resist its action for a greater length of time. It is not uncommon to see large surfaces of muscles and even of bones exposed, the skin and cellular tissue having been completely dissected away by the disease. The blood-vessels yield more readily in hospital than in the forms of dry gangrene; and hence in the former, hemorrhage, both venous and arterial, is very common, and in some cases both directly and indirectly becomes a cause of death. From this cause it happens that the gangrenous tissues frequently present a mottled appearance, from the hemorrhages of limited extent taking place from the smaller vessels destroyed in the ravages of the disease. Whilst there is a tendency to the coagulation of the blood in the vessels passing into and through the gangrenous mass, still the tendency is less and the coagulation far less perfect than in dry gangrene. This difference may be due to the more rapid progress of the disease as well as to differences in the constitution of the blood, and especially to differences in the quantity and quality of the fibrous element in the different forms of gangrene.

As far as my observations extend, the bones do not yield readily to hospital gangrene; and even when exposed, and in part surrounded by the disease, with the exception of slight exfoliation of

the outer table, little or no erosion or death takes place; and when the disease is arrested, granulations spring up rapidly and cover the exposed surface of the bones.

Several instances have come under my observation, in which gangrene existed in structures beneath an apparently sound skin. Thus, in the case of a Federal prisoner, who received a slight wound upon the external portion of the left thigh, just above the knee joint, at the battle of Chickamauga, and who suffered for several days before death with an abscess in the groin of the injured limb, from which sanious fetid matter issued, and who died apparently from the exhaustive effects of colliquative diarrhœa, resulting probably from the absorption of the products of the disorganizing tissues; the skin over the injured thigh and buttocks appeared sound, whilst the cellular and muscular tissues of the thigh and buttock were in a state of gangrene, presenting blue and green and greenish gray disorganized matter. In this case the muscular structures were so disorganized that they were crushed by the slightest pressure. Under the microscope, the muscular substance and structures appeared to be almost completely disorganized, and nothing but the fibrous tissue remained. Innumerable granules and granular masses, crystals of the coloring matter of the blood, prismatic crystals of the phosphates of ammonia, magnesia, and lime, altered blood corpuscles, detached masses of cellular tissue and of muscular fibres, in which the striæ were fast disappearing, together with oil globules, all pervaded by a fetid greenish sanious fluid, constituted the mass of the gangrenous muscles.

The disorganized structures were strongly impregnated with ammonia, one of the products of the disintegration of the nitrogenized constituents; and the normal acid reaction of healthy muscular structures was changed to a strongly alkaline reaction.

In another case, where the operation of ligating the brachial artery was performed, to arrest hemorrhage from a gangrenous wound in the fore-arm, involving structures around the elbow joint, the cellular tissue surrounding the artery was found to be in a gangrenous state, although no suspicion was entertained of the existence of gangrene before the operation was performed. It is probable that in this case the spread of gangrene had been very rapid along the fibrous tissue surrounding the great vessels and nerves.

I have frequently seen a narrow strip of apparently sound skin passing between two gangrenous wounds, and even passing across

a large gangrenous mass. This observation is well illustrated by the following case: —

Case IX. Illustrating the existence of sound skin between two large gangrenous wounds.

Case IX. David Shelton, Company G, 12th and 47th Regiments Tennessee Vols., private. Has been in Confederate service since the 16th of December, 1861. Age, thirty-four. Native of Kentucky. Stout, well-built man. Sandy hair and beard. Scraggy beard and moustache.

Wounded on the 1st of September, 1864, at Jonesboro', Georgia. The ball passed directly through both eyes and through the nose, leaving the bridge of the nose untouched. The patient says that when the ball struck his eyes, he perceived a vivid flash of light, and then all was darkness, as if he had been suddenly shut up in a dungeon under ground. The knees gave way somewhat, but the wounded soldier did not fall; and he says that he immediately put his hand to the wound and passed his finger through the places formerly occupied by the eyes, and through the round hole in the bridge of his nose, and felt a gelatinous mass of torn flesh and blood. He then knew that both eyes were gone, and quietly sat down in the trenches until evening, when the wounded were removed. His consciousness never forsook him. Was removed that night to Griffin, Georgia, and was from thence transferred to the Blind Asylum Hospital in Macon. The gangrene appeared in the wound about ten days afterwards, and he was transferred to the Empire Hospital, Vineville.

After the appearance of the gangrene, his mind wandered, and he had no recollection of what passed during the active progress of the disease. The wounds in both eyes were swollen, with everted edges. The eyelids were especially swollen, and the patient presented a most distressed and horrible spectacle. I visited his case frequently during his convalescence, and found him always cheerful and happy. He was in the habit of singing merry songs, and in fact was the most cheerful and happy man apparently in the entire hospital.

I executed the following drawing, October 25, 1864, with the design of illustrating the fact that a small strip of skin and tissue may remain uninjured, although surrounded on both sides and even undermined by hospital gangrene. See Plate 5.[1]

At the time of the execution of this drawing, the wounds presented a healthy granulating surface, and the patient was in good health and cheerful spirits. He took great interest in the execution of the drawing, and begged for a copy; and after its completion, he sang several songs.

On the next day, October 26, this soldier was sent home under the charge of a companion. (The patient was a man of family — a wife and six children.)

[1] Omitted.

Appearance of the surface after removal of the gangrene.

When gangrene terminates favorably, the surface from which it is removed presents a bright red and scarlet, exquisitely sensitive mass of luxuriant granulations, which are highly vascular, and bleed upon the slightest touch. So sensitive is this surface, that the most gentle touch will frequently cause the patient, even though he may be a stout, brave soldier, to cry like a child. Although the appearance here described is highly favorable, at the same time many cases terminate fatally, even after the removal of the gangrene, from various causes, as exhaustion of the system by profuse suppuration, the depressing effects of the previous disease, the permanent derangement of the digestion, caused during the active stages of the disease, by bed sores, by pyæmia, and by diarrhœa.

After the establishment of healthy granulation, the bones which have been denuded by the gangrene will frequently be rapidly covered by an abundant growth of granulations. When the bones of the leg have been denuded in a stump after amputation, I have observed a most luxuriant crop of granulations sprouting out of the medulla of the bone, like a fungus growth. In most cases the granulations die, and the injured bone separates. When the bone has been exposed in its length, the outer table will frequently scale off, and the separation of bone proceeds no further, and the new tissue forms over the denuded bones.

The following case presents a good illustration of the condition of extensive wounds, after the removal of hospital gangrene : —

Case X. Illustrating the appearance of the surface after the removal of hospital gangrene.

Case X. Captain John F. Cox, Company D, 29th Regiment Mississippi Vols., Brantley's Brigade, Anderson's Division. Age, thirty-one. Height, five feet seven and one half inches. Weight in health, one hundred and seventy pounds. Suffered with typhoid fever in 1855, and had measles in childhood, but otherwise has been perfectly healthy. Has been in Confederate service since 27th of April, 1861. Black hair and eyes. Florid, dark complexion. Has been wounded four times, slightly, before the present wound.

Wounded 31st of August, 1864, at Jonesboro', Georgia. Minie-ball passed through left ankle. Amputation performed after he was taken prisoner, at Federal field hospital, about midnight. Remained two days in the Federal field hospital, which was a large tent crowded with wounded. His wound was not examined or dressed during this time. On the third day was removed to a small church in Jonesboro', crowded with about eighty wounded men. His wound was not examined until the fifth day, and was not dressed until the seventh day. During these

seven days no attention was paid to the wound, and the stump was not even wet once with cold water.

When examined on the fifth day, in the church, the wound was found to be gangrenous, and the patient was then removed into a private house about one hundred yards from the church.

On the seventh day, the gangrenous stump was burnt with strong nitric acid. Erysipelas also appeared. Two days after this, Captain Cox was recaptured by the Confederates, after the Federals withdrew from Jonesboro'. He was first sent to Lovejoy's Station, and from thence to the Ocmulgee Hospital in Macon; and was finally transferred to the Empire Hospital, on the 16th of September.

At this time the gangrene was progressing in the inflamed and swollen and erysipelatous stump. The free use of nitric acid as a cautery, with tincture muriate of iron and quinine internally, arrested the disease in one week.

On the 5th of October, I executed the following outline sketch, Plate No. 6.[1] At this time the wound presented a bright red, granulating, highly sensitive surface, which secreted pus in large quantities. The end of the fibula, which had been exposed, is now covered with a rich crop of luxuriant granulations. They are also seen rising out of the medullary cavity of the tibia.

The patient has been greatly exhausted and reduced in flesh by the preceding disease, and by the profuse suppuration. Pulse weak and thready; ninety-eight per minute. Suffers with great oppression at the chest, and eructates continually. Has no appetite, and suffers with constant nausea. Bowels loose; complains of great weakness. Manifests great nervous depression and irritability.

Whilst I was executing the drawing, a large drove of cattle, which were passing along the road to Vineville, were stampeded by the whistle of the passing engine and cars, and rushed down the streets of this tent hospital. The Captain was greatly agitated, and cried out, fearing lest one of the cows might run against his injured leg.

This case progressed unfavorably. Suppuration very profuse from the stump. The stomach gave way entirely, and he appeared to suffer from acute gastritis, attended with much burning pain in the stomach, and constant nausea and vomiting, retching and belching. A large abscess formed in the back, and discharged large quantities of pus.

This gallant soldier died October 31.

Progress of hospital gangrene when engrafted upon an old sore.

According to Mr. Blackadder, when the disease attacks an old sore, where a considerable depth of new flesh has been formed, the first thing generally observed is a small dark-colored spot, usually situated at the edge of the sore. But he states that in several cases of ulcers, the disease,

[1] Omitted.

when carefully watched, was found to begin in the form of a vesicle, filled with a livid, or brownish black fluid, which afterwards burst, and assumed the appearance of the dark colored spot which is commonly noticed. Mr. Blackadder always found, that when there had been a considerable bed of new flesh formed, the phagedænic ulceration made comparatively a very slow progress, and put on rather the appearance of mercurial phagedæna, until the morbific matter had found access to the natural texture of the part, when the progress of the disease became suddenly accelerated, acute inflammation supervened, and a large slough was formed. According to the same careful observer, when the disease attacks a recent gunshot wound, the discharge, two or three days after infection, is found to be lessened, and to have become more of a sanious than purulent nature. The sore has a certain dry and rigid appearance; its edges are more defined, somewhat elevated, and sharpened; the patient is sensible of a change in the usual sensation in the sore, and complains of the occasional stinging sensation, resembling that produced by the stinging of a gnat. At this period, but sometimes a day or two later, the integuments at the edge of the sore become inflamed, and the surface itself assumes a livid or purple color, and appears as if covered with a fine pellicle, such as is formed on a coagulum of blood. When left to itself, this pellicle gradually increases in thickness, forming what has been termed a slough. At this period the progress of the disease is hardly in any two instances precisely alike. Generally in the course of from five to ten or fifteen days, a thick, spongy, and putrid looking slough is formed over the whole surface of the sore, and which is more or less of an ash, or blackish brown color. When the pellicle is destroyed, — as frequently happens in the process of cleaning, — it is not in every case reproduced, but an offensive matter begins to be discharged, which becomes daily more copious, is of a dirty yellow color, and ropy consistence, and is very adherent to the sore. The substance which formed the apparent bottom of the sore or wound is raised up, and pushing the edges, makes the sore appear considerably enlarged. The edges, which are usually jagged or pectinated, become extremely irritable, of a deep red color, and dotted in their inner surface with numerous small elevated and angry looking points, which may be considered as one of the characteristic marks of the disease. The surrounding integuments become indurated and inflamed, assuming not unfrequently an anserine appearance; and the patient complains of a constant burning lancinating pain. In the vicinity of the sore the integu-

ments become more and more of a dark red color, in consequence of the violence of the inflammation, which is of an erysipelatous nature, and apt to terminate in sloughing, and carry off the patient. However, the inflammatory symptoms are sometimes mild, and in other cases exceedingly violent, — a fact accounted for by differences of constitution.[1]

As the disease progresses, the complexion assumes an unhealthy, dusky, leaden hue, the eyes express anxiety, depression, and nervous irritation and exhaustion, the pulse is small, frequent, and feeble, and indicates an irritable, enfeebled state of the nervous and muscular systems.

Appearance of the complexion, and expression of the countenance during the progress of hospital gangrene.

It is possible by these symptoms alone to decide in many cases whether gangrene is present, and whether it is progressing or disappearing.

In some cases the progress of the disease is rapid and terrible. The edges of the wound become hardened and everted, the surface of the wound rises up into a pulpy, ragged, gray and greenish mass. When the sloughs are detached, the disease attacks other adjacent structures from day to day, extending its ravages both in length and breadth, and involving aponeuroses, muscles, blood-vessels, nerves, tendons, the periosteum, and bones and joints.

Ravages of hospital gangrene.

In a case of hospital gangrene supervening upon a slight wound of the scalp, which came under the notice of Mr. Blackadder, half of the cranium was denuded, the bones having become as black as charcoal, and the integuments detached posteriorly to the second cervical vertebra, and anteriorly to the middle of the zygomatic process of the temporal bone. In another case, which was originally a simple flesh wound, the muscles, large arteries, and nerves of both thighs were exposed and dissected, the integuments and cellular substance being entirely removed, with the exception of a narrow strip of the former, which remained on the outer side of the thigh.

In still another case, the integuments and cellular substance on the anterior part of the neck were destroyed, exposing the trachea, which was attacked by the disease. Most commonly, after the muscles have been exposed, they continue to be gradually dissected; their connecting membrane is completely destroyed, and they are left covered with an offensive, greasy looking matter. When a muscle has been invaded by the disease, it sometimes swells to a great size, loses its irritability, and assumes the appearance of a large coagulum.

[1] *On Phagedæna Gangrænosa*, pp. 21–22.

As the disease advances, hemorrhage from small vessels is a common occurrence, and in the more advanced stage some of the large vessels are apt to give way, and the patient is frequently destroyed by the consequent hemorrhage.

In the last stage of the disease, as it occurred in the military hospitals at Bilboa, as described by Dr. Hennen, the surface of the sore was constantly covered with a bloody oozing, and on lifting up the edge of the flabby slough, the probe was tinged with dark colored, grumous blood, with which also its track became immediately filled. Repeated and copious venous bleedings now came on, which rapidly sunk the patient; the sloughs, whether they fell off spontaneously, or were detached by art, were quickly succeeded by others, and brought into view thickly studded specks of arterial blood.

At length an artery gave way, which was generally torn through in the attempt to secure it with a ligature; the tourniquet or other pressure was now applied, but in vain; for while it checked the bleeding, it accelerated the death of the limb, which became frightfully swelled and horribly fetid. Incessant retchings came on, and with coma, involuntary stools, and hiccough, closed the scene. Often, however, the patient survived this acute state of the disease, and sunk under severe irritation, absorption of putrid matter, and extensive loss of substance, with common hectic symptoms.

CHAPTER SECOND.

MICROSCOPICAL AND CHEMICAL INVESTIGATIONS UPON HOSPITAL GANGRENE.

Microscopical Examination of the Gangrenous Matter. — Consists of the Various Structures in a Disorganized State, together with the Products of the dead Disorganizing Tissues. — The Pus Globule absent in the Gangrenous Mass. — The Appearance of the Pus Globule in Hospital Gangrene a Favorable Sign. — Animalcules present in Considerable Numbers in the Gangrenous Matter. — The Results of these Microscopical Observations clearly sustain the View that Hospital Gangrene is due to the Action of an Irritant Organic Poison, which, after the Manner of a Ferment, is capable of inducing such Decomposition in the Tissues and in the Blood, that all Development of the Cellular Elements of the Liquor Sanguinis into Cells or Fibres, or into Pus, is arrested. — Chemical Examination of the Gangrenous Matter. — Observations of Surgeon Jackson Chambliss, of Camp Winder Hospital. — First Chemical Examination of Gangrenous Matter by Mr. Cruikshank, Chemist of the Royal Artillery. — Microscopical Examination of the Pus secreted by Wounds, after the Removal of Hospital Gangrene. — Changes of the Blood in Hospital Gangrene. — Illustrative Cases. — Analysis of Blood. — These Investigations tend to Establish that the Action of the Poison of Hospital Gangrene is attended with both Local and Constitutional Symptoms of Inflammation, and that the Changes excited both locally and constitutionally by the Gangrenous Poison, are such that the Products and Phenomena of the Disease vary to a certain Extent from those of Ordinary Inflammation.

MICROSCOPICAL EXAMINATION OF THE GANGRENOUS MATTER.

Microscopical examination of gangrenous matter.

I HAVE made numerous microscopical examinations of the gangrenous matter, and discovered that it consists of the various structures in a disorganized state, together with the various products resulting from the altered physical and chemical changes. Innumerable granules are observable, with detached masses of fibrous and muscular tissue, broken blood-vessels, disorganizing blood corpuscles, and in some cases, especially when strong mineral acids have not been applied to the gangrenous wound, crystals of the triple phosphates.

Animalcules abound in gangrenous matter.

Animalcules of simple organization, and endowed with active rotary motion, abound in hospital gangrene. The number of these vary very much, both in the gangrenous matter and in the urine, with the temperature of the surrounding atmosphere. In cold weather they are less numerous than in hot weather. When the decomposition of the living tissues has taken place under the sound skin, I have also found that the animalcules are not present, or if present, exist in small numbers.

No proof that these animalcules are in any manner connected with the origin and spread of hospital gangrene.

After a careful examination of various vegetable and animal matters exposed to the atmosphere under similar circumstances of temperature and moisture, I have come to the conclusion that in the present state of our knowledge we are unable to demonstrate that these animalcules are in any way connected with the origin and spread of hospital gangrene. The gangrenous matter appears to afford a nidus in which these simple forms of animal and even of vegetable life are rapidly generated and multiplied. As far as my observations extend, they show that these animalcules will be generated with similar rapidity in urine containing albumen, or in any nitrogenized body undergoing putrefaction in a warm, moist situation, like that of the wards of a hospital. The warmth of the human body also, without doubt, affords a most favorable condition for the rapid development of the simpler forms of animal life. I have been unable to discover any forms of animalculæ peculiar to hospital gangrene.

With reference to the simpler forms of vegetation, they are also present, but in less abundance than those of animal life; and in like manner these vegetable organizations are not peculiar to hospital gangrene, but are found in all organic matter undergoing decomposition under similar circumstances.

I have been unable to establish any relation between the rapidity of the spread of the disease and the number and character of the living organisms, and have even found them absent in the most extensive gangrene which had been excluded by the sound skin from the atmosphere.

These microscopical investigations have thus far afforded only negative testimony upon the animalcular origin of hospital gangrene.

Pus globule absent from gangrenous matter.

I have determined, by careful microscopical examinations, that the pus globule is not formed in true gangrenous matter. I do not wish to be understood as asserting that pus is never formed in a gangrenous wound. It frequently happens that gangrene may exist in certain portions of a wound, whilst in other portions the reparative process is active. So also portions of the structures may resist for a time complete death, whilst passing into a state of gangrene, and may present some of the changes of inflammation, and yield some of the products of inflammation, one of which may be an altered and imperfectly developed pus. In the healthier portions of a gangrenous wound, we may therefore have the formation of pus, whilst in the gan-

grenous mass this evidence of the organizing force is absent or only accidentally present.

After gangrene has set in, the reappearance of pus should be regarded as a favorable sign, indicating an attempt at organization, and an improvement in the plastic powers of the parts immediately surrounding the altered gangrenous matter.

Appearance of the pus globule a favorable sign in gangrene.

The following figures in Plate 7,[1] will illustrate the appearance of the gangrenous matter.

In the local manifestations of the actions of many organic poisons, as those of small-pox, syphilis, gonorrhœa, of sibbens or sivvens, of yaws, and of various skin diseases, the formation of pus is invariably observed.

In the extensive sloughing of tissue, so often observed accompanying necrosed bones, the formation of pus is universally present.

We might illustrate this by numerous cases, but the following instance will be sufficient to represent a class of cases so common in our present struggle for independence: —

Case XI. Charles R. Barker, Company D, 7th Regiment Louisiana Vols. Age, twenty-three. Height, five feet eight inches. Weight in health, one hundred and fifty-four pounds. Brown hair; brown eyes; nervo-sanguine temperament. Wounded in right leg, at first battle of Manassas, 21st July, 1861. Minie-ball struck the lower portion of the right femur, about two inches above its inferior termination in the knee joint. The bone was not fractured; the ball simply buried itself in the femur. The force of the ball must have been greatly spent, otherwise it would have passed entirely through the bone. The wound inflamed, and assumed an unhealthy appearance; and twenty days after the reception of the wound the thigh was amputated near the middle, or about eight and a half inches from the trochanter major, in the general hospital at Culpepper Court House, Virginia. After the operation the stump did not heal, and the surfaces assumed an unhealthy, suppurating state. The patient was confined to his bed for more than four months, during which time there was but little progress in the healing of the wound; the discharge continued, although there was partial union of the flaps. At the end of this period the patient attempted to walk about on crutches, and on the 20th of February, 1862, whilst the snow covered the ground, went out. This caused the stump to inflame, an accumulution of pus took place around the bone, and the flaps were opened.

At this time, large quantities of offensive pus were discharged. The

[1] Omitted.

patient was so much reduced by this condition of the stump that he was compelled to remain in bed until the 1st of June. After this date the wound slowly improved, and considerable portions of the flaps united. In December, this patient was able to travel to Georgia, and entered the general hospital at Augusta, January 20, 1863, and at this time came under my treatment.

After careful examination, the bone was found to be extensively necrosed, and the discharge from several fistulous openings was profuse and fetid. At the time that this patient entered the general hospital, he was in a most weak and feeble condition, and suffered from hectic fever, consequent upon the condition of the stump. The pulse was rapid and feeble, and the complexion dusky and unhealthy. The sloughing went on rapidly, until the bone of the thigh was exposed and denuded. The patient was placed upon the tartrate of iron and potassa, sulphate of quinia, generous diet and stimulants, with opiates whenever necessary. Under this treatment the patient gathered sufficient strength to resume the use of his crutches, and on the 9th of March, at his urgent request, was allowed to visit some friends at Union Point, Georgia. Returned to the general hospital in Augusta in a miserable condition; wound suppurating profusely; bone sticking out more than one inch from the stump; extensive sloughing of the structures around the bone. Strength completely exhausted. The plan of treatment above described was again instituted, and the wound dressed with a liniment of simple cerate, containing morphine and tincture of iodine. The pulse was so rapid and feeble, and the prostration of the nervous and muscular systems was so great, that fears were entertained that this patient would not recover. Under the free administration of tonics and stimulants, combined with the most nutritious diet, however, the general health gradually improved. The bone, which was examined daily, now presented unmistakable evidences that it was detached from the shaft above.

On the 24th of May, 1863, I placed the patient under the influence of chloroform, and abstracted the bone. Length of dead bone, seven and one half inches. The entire length of the femur from the trochanter was abstracted, and the thigh remained without any bone throughout its extent.

The following Plate, No. 8,[1] represents an outline sketch of this dead bone.

After the removal of the bone, the patient rapidly improved in health.

Notwithstanding the continuance of this distressing source of irritation, and the prolongation of the struggles of nature during the exhaustive processes necessary for the separation of the dead bone during a period of twenty-two months and three days, and notwithstanding the feeble state of the patient, pus was always secreted.

[1] Omitted.

Had this case at any time been attacked by hospital gangrene, the secretion of pus would have ceased almost immediately, and the destruction of tissue would have been greater in the course of twenty-two hours than in the whole period of twenty-two months.

Even in the phagedænic ulcers arising from the abuse of mercury, in constitutions worn down by vicious habits, deteriorated by the abuse of alcoholic stimulants and bad diet, and poisoned by the syphilitic virus, the spread of the ulcerations and the detachment of the tissues is attended with the constant formation of pus. Whether we view this fluid as resulting from the degeneration of the affected fluids and tissues in these diseases, or as analogous to a secretion thrown out by the parts surrounding the immediate focus of the inflammation, destined to dissolve the diseased tissues, or as one of the natural stages of the changes of coagulable lymph, and of granulation cells in the progress of inflammation, it is nevertheless true that the absence of pus in any wound or ulcer which is rapidly enlarging its bounds, indicates marked derangement in the changes of the solids and fluids, and in the action of the forces concerned in ordinary inflammation. Whilst inflammation is justly called a diseased action, and is necessarily attended with derangements in the constitution and forces of the affected part, and in the processes of nutrition and secretion, at the same time it is governed by definite laws, and often progresses in such a manner as to preserve the life of an animal, and the functions of the part inflamed; therefore uniform perturbations of the process as ordinarily observed, indicate clearly the action of some definite cause. And hence also we may correctly speak of a derangement of even the changes characteristic of inflammation.

Pus formed in phagedænic ulcers arising from the abuse of mercury in constitutions broken down by vicious habits and bad diet.

If we accept the definition that inflammation is "an alteration in the healthy structure and function of a part, accompanied by a perverted condition of the blood and capillary blood-vessels, ordinarily attended with redness, heat, and swelling, and inducing more or less febrile disturbance in the general system," then in hospital gangrene we observe all the essential conditions of inflammation. In this disease, there is an alteration in the healthy structure and function of the affected parts, as indicated by the change of color and structure, the fetid odor, and the suspension of secretion and healthy nutrition; there is an altered condition of the blood, as manifested by the dark livid areola, by passive hemorrhages, and by the dusky hue of the complexion; there is derangement of the

Essential conditions of inflammation present in hospital gangrene. Observations on inflammation.

capillary circulation, as manifested in the effusion in and around the gangrenous tissues, and the intense congestion of the blood-vessels in immediate contact with the diseased part; there is redness, pain, heat, and swelling; and there is more or less febrile disturbance of the general system, as manifested in the rapid, feeble pulse, the marked diurnal elevations and depressions of temperature, the depressed spirits, and deranged muscular and nervous actions. When the injury of the living tissues is simple, as in a wound caused by a mechanical instrument, the natural result of inflammation appears to be the production of such a fibrous effusion as will surround and isolate the injured or diseased parts. In such uncomplicated cases of the inflammatory process, there will be observed in the injured structures the perversion of nutrition, the destruction of capillaries, the alteration of blood, the exudation of lymph, and the formation of pus; and around the focus of actual destructive changes, the blood-vessels are distended with blood, and exude the plastic lymph from which the coagulable elements separate, containing the germ cells destined not merely to form a structure inclosing the diseased part, but also by their development to form a tissue which will replace that which has been destroyed. The living cells of the lymph may either form tissue or granulations, or they may be arrested and altered in their development and form the pus globule. With regard to the vital properties of coagulable lymph, its essential character is its power to develop itself, and to assume organic structure. The character and rapidity of the transformations and development of the living cells of the lymph effused in inflammation, will depend chiefly upon the cause exciting the disease, and upon the powers of the general system, and upon the constitution of the blood, and consequently of the lymph itself. Thus, in open wounds, when the constitutional forces are deficient, the granulations may be arrested in their development, or they may become more granular, and lose the well-marked characters of their nucleus, and acquire the structure of the pus cell.

This degeneration of the lymph cells and granulations into pus, should however by no means be taken as an evidence that the natural powers of the system are defective, or that the constitution of the blood and lymph are abnormal, for it is invariably present in all wounds which do not heal by immediate contact or by the first intention, and appears to be intimately associated with, if not absolutely necessary to the successful healing of the injured parts. It is rather the amount and character of the suppuration which indicate the extent to which the powers are involved. We should

therefore regard pus on the one hand as a secretion, destined to dissolve certain organic tissues, and to shield by its bland properties delicate granulating surfaces from the direct action of the atmosphere; and on the other hand, as a rudimental, imperfectly developed, or degenerated substance, essentially similar to the materials of the lymph of inflammatory exudation, or of granulations, but which has either failed of being developed like them, or which has degenerated after a certain amount of development.

In hospital gangrene the lymph effused around the focus of disease possesses the power of coagulation, as in other varieties of inflammation, as I have determined by actual experiment, and there appear to be all the conditions necessary for the arrest of the disease, by the development of coagulable lymph through nucleated cells into the fibrous and fibro-cellular or connective tissue; but the characters of the irritant poison are such, that the products of inflammation, together with the blood-vessels and the blood itself, are rapidly disintegrated. The life of the blood is destroyed by the gangrenous poison, and the fluids and living organizable matter and cells upon which the progress of inflammation depends, are poisoned. It results from this that the liquor sanguinis, effused within the diseased structures, does not pass into the state of pus, as in healthy wounds, and in the common furuncle and carbuncle, or even in erysipelas and the pustules of small-pox, and the exudation corpuscles are so poisoned and disorganized that they are not further changed in either a progressive or descending series, and wherever the limiting fibrous wall is thrown out with its cellular elements, it is in like manner destroyed whenever it is reached by the poison. All the changes of the blood characteristic of ordinary inflammation may be present around the gangrenous part, as the increase of liquor sanguinis, with increase of its albumen and fibrin, both actually and relatively to the blood corpuscles, aggregation of the red corpuscles, and increase of the colorless or lymph corpuscles; but no arrest of the disease will take place as long as the poison is capable of exciting rapid change and decomposition, after the manner of a nitrogenized ferment, in the products of inflammation.

In hospital gangrene the lymph effused possesses the power of coagulation, and there appear to be all the conditions necessary for the arrest of the disease by the organization of the plastic elements; but the characters of the irritant poison are such, that the products of inflammation together with the blood-vessels and the blood itself are rapidly disintegrated.

If, in a wound infected with hospital gangrene, the morbid process did not advance as in any other wound, from the centre to the circumference, with the central focus of

The rapidity of the progress of hos-

pital gangrene limited to a certain extent by the peculiar action of the poison.

infection and active disorganization surrounded and guarded, as it were, by a circle of active congestion, with blood-vessels loaded with colored corpuscles, with interrupted circulation and exudation of plastic liquor sanguinis, and with venous and lymphatic absorption greatly impeded, if not altogether arrested, the gangrenous poison would enter directly and rapidly into the circulation, and prove speedily fatal. And even after the excitation of inflammation, in virtue of the irritant properties of the poison, in every case of hospital gangrene of any standing, more or less of the poison is absorbed, and affects the general system. The extent of this absorption of the deleterious agent or agents will depend upon many circumstances, but chiefly upon the character and extent of the inflammatory processes around the immediate centre of infection.

Explanation of the relief sometimes afforded by hemorrhage in hospital gangrene.

We may in these facts find some explanation of the relief sometimes afforded by hemorrhage in hospital gangrene. The poison is diluted and washed out by the blood at the same time that the inflammatory congestion is relieved by the hemorrhage.

Hospital gangrene due to the action of an irritant organic poison, which after the manner of a ferment is capable of inducing decomposition in the tissues and in the blood.

Finally, the results of these microscopical observations clearly sustain the view that hospital gangrene is due to the action of an irritant organic poison, which, after the manner of a ferment, is capable of inducing such decomposition in the tissues and in the blood, that all development of the cellular elements of the liquor sanguinis into cells, fibres, or into pus, is arrested.

CHEMICAL EXAMINATION OF THE GANGRENOUS MATTER.

Chemical examination of gangrenous matter. Animal poisons generated during the progress of hospital gangrene.

From the disintegration of the organic constituents of the structures in hospital gangrene, a number of compounds result, which are either unknown or are very rare in the living organism. Some of these products, when absorbed, act as animal poisons upon the muscular and nervous systems, and tend to disorganize the blood and derange the actions of the alimentary canal. When absorbed in large quantities, these products sometimes act as irritants to the intestinal canal, and the patients are sometimes destroyed by the diarrhœa consequent upon their action. The extent of these changes is well illustrated by the fact, which I have demonstrated by microscopical and chemical investigation, that ammonia is some-

times generated in such large quantities in gangrenous muscles, as not only to give a strong alkaline reaction to the naturally acid muscular juices, but also to cause the precipitation of the phosphates in the form of well-defined crystals of triple phosphate. These crystals were chiefly prismatic, and were found in great numbers in the muscular structures and in the alkaline gangrenous juices pressed out of the muscles. The products of the dead tissues which prove when absorbed so deleterious to the patient, are nevertheless harmless to certain forms of animal life. Thus, the common maggot is rapidly developed and multiplied in the gangrenous matter, and if allowed to remain, will consume the dead tissues completely. Such a cleaning of a gangrenous wound is said in some cases to have been beneficial.

The full analysis of the gangrenous matter will be reserved for the final report; we will content ourselves for the present with a brief reference to the great complexity of the investigation.

Complicated nature of the materials entering into the gangrenous changes.

Thus, in a gangrenous mass of matter upon the thigh or upon any muscular portion of the human body, there are more than thirty different organic and mineral bodies in various states of combination which should be examined, besides the various products resulting from their decomposition.

There is the skin and its excretions; the blood, with its water colored and colorless corpuscles, liquor sanguinis, extractive and fatty matters, and various mineral salts (hæmatin, globulin, cell membrane, extractive matters, serolin, phosphorized fat, cholesterin, saponified fat, iron, phosphorus, sulphur, fibrin, albumen, colorless corpuscles, exudation corpuscles, phosphates of soda, potassa, lime, and magnesia, sulphates of soda and potassa, and chlorides of sodium and potassium); muscular tissue (muscular fibre, syntonine, gelatine, albumen, creatine, creatinine, inosic acid, lactic acid, fat, sulphur, and phosphorus, chlorides of sodium and potassium, sulphates and phosphates of the alkalies and alkaline earths); nervous structures, with various fats and phosphorus: elastic and fibrous tissue, and the structures of the capillaries, veins and arteries. In hospital gangrene we have all these substances, many of which are highly complex in their chemical constitution, mingled together in a disorganizing decomposing mass. The problem involves not merely the determination of the peculiar poison inducing gangrene, but also the various products resulting from the chemical changes which it induces in these highly complex organic compounds.

During my investigations upon hospital gangrene in the hospitals in and around Richmond, Virginia, in the month of August, 1863, I received the following interesting communication from Surgeon J. C. Chambliss, of Winder Hospital: —

WINDER HOSPITAL, DIVISION No. 2,
24th August, 1863.

DR. J. JONES, SURGEON P. A. C. S.

SIR, — You will please accept a specimen of matter taken from a violent case of hospital gangrene. The wound is situated in middle third of thigh, received at Gettysburg, July 3, 1863. No remedies had been applied when the matter was taken.

Observations of Surgeon J. C. Chambliss upon the chemical properties of hospital gangrene.

I send you also a small vial, containing a pink-colored fluid or precipitate, caused by the action of nitric acid upon a solution of this matter in distilled water. Now I have tried this experiment with matter taken from this and other wounds affected with gangrene, and have the pleasure to state that the results have been in every case similar, namely, a beautiful pink-colored precipitate.

Pink precipitate produced by the action of nitric acid upon gangrenous matter.

Again, I have tried the action of the acid upon healthy pus, taken from a wound which had been gangrenous, and find only a white coagula; also upon pure blood and this pus mixed, but the result is similar to that from healthy pus alone.

Again, I thought probably this peculiar precipitate of the gangrenous matter might be the result of putrescence or the presence of sulphuretted hydrogen gas. This, however, I disproved by testing matter taken from the body of a decayed rat, which was acted upon, and a straw-colored precipitate the result, the usual action of the acid upon animal tissue.

I have also discovered that the peculiar pink-colored precipitate is produced in the wound when the acid is applied, the parts being thoroughly gangrenous, which I at first took for blood, but since, I am satisfied that it is the action of the acid upon this element, if I may so call it. Now the obtained precipitate, so peculiar in color, and so unlike that obtained from healthy pus, or animal tissue generally, and my knowing so well the specific action of nitric acid, and observing a fluid of this color in the wound when it was applied, induced me to try and discover the cause of hospital gangrene. I have tested with pyroligneous acid, nitrate of silver, and other remedies, but nothing has appeared similar to the action of nitric acid.

Gangrenous matter I find is highly acid, reddening litmus paper; the smell indicates the same when freshly taken from the wound.

You will please be so kind as to repeat my experiments, and tell me what this precipitate results from.

I have noticed that the color of the pink precipitate is permanent only when the vessel is kept well stoppered; otherwise it will fade to a

dirty whitish color, in a few hours, by exposure to air, probably by the absorption of oxygen.

I regret to say that my limited knowledge of chemistry, and my poor apparatus for testing, has brought me to this perplexing halt, the solution of which will be long remembered and highly appreciated bv

Yours, most respectfully,

J. CHAMBLISS,
Surgeon P. A. C. S.
In charge Division No. 2.

P. S. — I am making some interesting experiments upon dogs, relating to the same subject, which I will communicate if the results prove important. J. C.

Nitric acid not an infallible test for hospital gangrene. Results not uniform.

When the specimen of gangrenous matter tested with nitric acid, referred to by Dr. Chambliss, reached me in Richmond, the peculiar pink color had disappeared. A few days afterwards, I visited Winder Hospital, and repeated with Surgeon Chambliss the experiments upon gangrenous matter and healthy pus. The results were not uniform, and I was led to believe that this was not an infallible test for the presence of the disease.

The first chemical examination of the matter of hospital gangrene, appears to have been made by Mr. Cruikshank, chemist of the Royal Artillery; and it was published by Dr. Rollo, Surgeon-General to the Royal Artillery, in the first edition of his work on Diabetes,[1] under the head of "A Short Account of a Morbid Poison acting on Sores, and of the Method of destroying it."

The following are the remarks of Mr. Cruikshank upon his experiments instituted for the purpose of examining the matter of ulcers, which, from the careful description of Dr. Rollo, were evidently nothing more nor less than the disease now denoted hospital gangrene: —

Investigations of Mr. Cruikshank into the chemical nature of the matter of hospital gangrene.

"The matter of this sore is sparingly soluble in water, but readily diffused through it, producing a milky appearance; pure volatile alkali first reduces it to a transparent jelly, and after some time dissolves the greatest part; a similar effect is produced on pure pus. These solutions are but partially precipitated by acids, particularly the sulphuric. The tinctures of litmus and Brazil-wood are not changed by this matter; it does not, therefore, possess either acid or alkaline properties. If to the filtered solution of this matter in distilled water a little nitrated silver be added, a whitish colored precipitate will be produced. Similar precipitates, but much more copious, are occasioned by nitrated and muriated mer-

[1] London, 1797.

cury. When pure pus is treated in this way, these precipitates, particularly that by muriatic mercury, have somewhat of a different appearance, which it would be difficult to describe. The fetid smell is somewhat changed by lime-water, but not destroyed; the sulphuric acid rather increases it; a similar effect is produced by alcohol, and by the alkaline solution of arsenic. A decoction of the Peruvian bark does not destroy the fetor. This, however, is effected by the nitrates and muriates of mercury, by the nitrous acid, but most completely by the oxygenated muriatic acid and gas. Nitrated silver produces very little change, either in its color or smell, a circumstance the more remarkable as this salt possesses the property of destroying the most offensive smells, even that of the matter of cancer.

"It must be allowed that the offensive smell of the matter of this sore is produced by that part of the discharge which is altered from the nature of pure pus; for we know that every ill-conditioned discharge has more or less smell, while good pus has none. It is a known fact in chemistry, admitting of few exceptions, that a substance cannot have its smell totally destroyed or altered, without having its properties changed at the same time. If therefore this peculiar matter, by the addition of nitrated or muriated mercury, the oxygenated muriatic acid, etc., should have its smell completely destroyed, there is every reason to believe that its peculiar properties will be so also; and should it be capable in its original state of producing an ill-conditioned action in sores, the addition of such substances might prevent this mischief. If it should be supposed, therefore, that an acrid matter, somehow produced on the surface of sores, were capable of producing ulceration of a specific kind, and that this ulceration, like the venereal, should generate more of a nature similar to itself, capable of extending the mischief, and even of bringing on a general affection of the system, some important conclusions might be drawn from these experiments.

"1. It is easy to see that a sore once clean, might be preserved from the effects of the matter alluded to, by washing it at every dressing with a weak solution of nitrated mercury, or the oxygenated muriatic acid; and that even the generation of such matter might be entirely prevented by the same means.

"2. After the action has taken place, and before a general disposition is formed, it might be possible to put a stop to its progress by very active topical applications, such as should be capable not only of destroying the specific nature of the matter generated, but also the action itself. From the experiments already related, it is evident we should prefer in this case the most active mercurial preparations, such as red precipitate, not entirely deprived of its acid, or the muriated mercury; and if an active caustic were to be employed, we should have recourse to the strong nitrous acid applied in Mr. Humpage's method than the nitrated silver, especially as it may have also tl

changing the nature of the discharge. This consists in dipping a little lint in the acid and applying it to the part; it communicates less pain than any other caustic, except the nitrate of silver."

MICROSCOPICAL EXAMINATION OF THE PUS SECRETED BY WOUNDS AFTER THE REMOVAL OF HOSPITAL GANGRENE.

Microscopical examination of the pus secreted by wounds after the removal of hospital gangrene.

After the removal of hospital gangrene from a wound or ulcer, the pus secreted from the granulating surface will vary in its character, according to the extent to which the blood and general system have been involved by the disease. When the constitution of the blood has not been impaired, and the forces of the system remain unabated, the pus will present the usual characters of this fluid secreted from healthy granulating surfaces; it will be thick and cream-like, with numerous well-formed pus globules, and comparatively few granules. If, however, the constitution of the blood be deranged by the action of the gangrenous poison, and its fibrin be diminished below the standard usual in the phlegmasiæ, and the nervous and muscular forces be greatly reduced, the granulations will be slow in forming, and the pus thrown out will be thin and ofttimes fetid, with comparatively few pus globules, and numerous undeveloped granules.

The results of these microscopical observations confirm those previously recorded by Rokitansky and Mr. Paget: —

Observations of Rokitansky and Paget upon the varieties of pus and of inflammatory lymph.

"The conditions which are chiefly powerful in determining the character and tendency of inflammatory lymph, are three, namely: —

"1. The state of the blood.

"2. The seat of the inflammation.

"3. The degree of the inflammation.

"First, In regard to the influence of the state of the blood in determining the characters of an inflammatory product, Rokitansky has happily expressed it by saying that 'the product of the inflammation exists, at least in part, in its germ pre-formed in the whole blood.'

"Some indeed have supposed that lymph is only the liquor sanguinis, exuded in excess through the walls of the blood-vessels; but of this opinion we cannot be sure; and many facts, such as the occurrence of inflammatory lymph which does not spontaneously coagulate; *e. g.*, in herpes, will not agree with it. Still, it is not difficult to show that a certain character is commonly impressed by the state of the blood on the inflammatory product from it.

"I will not refer here to the cases of inoculable diseases in which one of the morbid material that was in the blood may be incorporated

with the product of a local inflammation, though in these the correspondence of the blood and the inflammatory product is manifest enough, but I will refer to cases that may show a more general correspondence between the two, a correspondence such that, according to the state of the blood, so is the lymph more fibrous or corpuscular, more characteristic of the adhesive or of the suppurative inflammation.

"Some of the best evidence of this is supplied by Rokitansky, in the first volume of his 'Pathological Anatomy.' In this work, he has shown clearly that the characters of inflammatory deposits, in different diatheses, correspond very generally and closely with those of the coagula found in the heart and pulmonary vessels; and that, in general, the characters of inflammatory lymph formed during life, are imitated by those of clots found in the body after death, when the fibrin of the blood may coagulate very slowly and in contact with organic substances.

"Other evidence may be obtained by examining the products of similar inflammations excited in several persons, in whom the state of the blood may be considered dissimilar. And here the evidence may be more pointed than in the former case; for, if it should appear that the same tissue, inflamed by the same stimulus, will in different persons yield different forms of lymph, we shall have come near to certainty that the character of the blood is that which chiefly determines the character of an inflammation.

"To test this matter, I examined carefully the materials exuded in blisters raised by cantharides plasters, applied to the skin in thirty patients in St. Bartholomew's Hospital. Doubtless, among the results thus obtained, there might be some diversities depending on the time and severity of the stimulus applied; still, it seemed a fair test of the question in view, and the general result proved it to be so. For, although the differences in the general aspects of these materials were slight, yet there were great differences in the microscopic characters; and these differences so far corresponded with the nature of the disease, or of the patient's general health, that at last I could generally guess accurately, from an examination of the fluid in the blister, what was the general character of the disease with which the patient suffered.

Thus in cases of purely local disease, in patients otherwise sound, the lymph thus obtained formed an almost unmixed coagulum, in which, when the fluid was pressed out, the fibrin was firm, elastic, and apparently filamentous. In cases at the opposite end of the scale, such as those of advanced phthisis, a minimum of fibrin was concealed by the crowds of corpuscles imbedded in it. Between these were numerous intermediate conditions which it is not necessary now to particularize. It may suffice to say that, after some practice, one might form a

opinion of the degree in which a patient was cachectic, and of the degree in which an inflammation in him would tend to the adhesive or the suppurative character, by these exudations.

"The highest health is marked by an exudation containing the most perfect and unmixed fibrin, the lowest by the formation of the most abundant corpuscles, and their nearest approach, even in their early state, to the characters of pus cells. The degrees of deviation from general health are marked, either by increasing abundance of the corpuscles, their gradual predominance over the fibrin, and their gradual approach to the characters of pus cells, or else by the gradual deterioration of fibrin, in which, from being tough, elastic, clear, uniform, and of filamentous appearance or filamentous structure, it becomes less and less filamentous, softer, more paste-like, turbid, nebulous, dotted, and mingled with minute oil-molecules. . . .

"Simple as the observations are, they may illustrate what often seems so mysterious, namely, the different issues of severe injuries inflicted on different persons. To what, more than to the previous or some acquired condition of the blood, can we ascribe in general the various consequences that follow the same operations on different patients? The local stimulus, and the conditions by which the inflammatory product finds itself surrounded, may be in all alike; but, as in the simpler case of the blister, the final events of the inflammation are according to the blood."[1]

CHANGES OF THE BLOOD IN HOSPITAL GANGRENE.

Changes of the blood in hospital gangrene. Impropriety of abstracting blood in this disease.

In this disease, it would be manifestly improper to abstract blood by venesection simply for analysis, when the lancet wound would be liable to be attacked by gangrenous inflammation, and the life of the patient might be sacrificed. This danger was especially to be dreaded in the crowded Confederate hospitals, scantily supplied with lint, rags, and utensils and instruments. My examinations, therefore, have been necessarily limited to the examination of the blood collected during hemorrhages and amputations.

As the period and mode of occurrence of hemorrhages were necessarily uncertain, I was dependent in a great measure upon the assistance of the medical officers and nurses for the careful collection and preservation of the blood.

I furnished a number of the medical officers at various times with porcelain capsules, suitable for the reception of from two hundred to two thousand grains of blood. My thanks are especially due to

[1] *Lectures on Surgical Pathology*, etc., by James Paget. Philadelphia, 1854, pp. 219-221.

Assistant-Surgeon A. A. Powell, of the Empire Hospital, Macon, Georgia, for valuable aid in the collection of the blood of hemorrhages occurring during various stages of hospital gangrene.

The first and most important subject in the relations of the changes of the blood to this disease, which we endeavored to investigate, was the character and quantity of the fibrin. We proceed at once to present such cases as we conceived were suitable for this investigation.

Case XII. Illustrating the characters of the blood in hospital gangrene.

CASE XII. Arnold Nowell, Company E, 57th Regiment Alabama Vols. Age, thirty-seven. Native of Washington County, Georgia. Black hair and eyes. Weight in health, one hundred and fifty-six pounds; now much reduced. Very dark, sallow, unhealthy complexion. Wounded July 20, 1864, at battle on Peach-tree Creek, near Atlanta. Was carried from the field of battle to Loring's Division Hospital in Atlanta. Minie-ball struck the fleshy part of the fore-arm about its middle. No bones were injured; and although there was some hemorrhage, the wound was considered by the attendant surgeon as slight. Remained in Atlanta one day, and was then transferred to the City Hall Hospital, in Macon. Had been in the City Hall Hospital for one month, and the wound was healing rapidly; the point of entrance was healed, but the point of exit was still open and suppurating. At this time the wound took on gangrenous inflammation; it became swollen, and was surrounded by a red, livid areola, and "burned most painfully." The gangrene, therefore, appeared about the 20th of August. Was transferred to the Empire Hospital, in Vineville, about the middle of September. At this time the muscles of the arm and fore-arm, in the region of the elbow joint, were extensively denuded, and the gangrene was spreading. Under the local application of nitric acid, and the internal use of quinine and tincture muriate of iron, the rapidity of the spread of the gangrene appeared to be somewhat diminished, but the disease was never entirely arrested.

October 1. — Sallow, dark, unhealthy complexion. The gangrene has made fearful ravages, denuding the muscles of the fore-arm and arm, exposing the condyles of the humerus, and the bones and tendons of the joint of the right arm. The muscles exposed present smooth red and purplish and greenish colors in different portions, and the raw surface is without any suppuration, and the gangrene is spreading chiefly along the inferior edges of the wound, and has penetrated the joint. The odor is insupportable. Patient nervous and restless. Bowels greatly disturbed, — running off continually. Had several most offensive and fetid evacuations, which diffused a most overpowering and disgusting gangrenous odor, whilst I was executing a sketch of the wound. Eye expressive of great dejection and nervousness; the w

arm and hand trembles upon the slightest exertion; has scarcely strength to lift a cup of water to his mouth, and the hand is so tremulous that it cannot retain the cup to the lips. Prostration of nervous power complete. Talks to himself, and although when aroused and directly interrogated gives a coherent answer, still his intellect is very sluggish, and his answers are slow and hesitating. In fact, his condition, when the attention is not directly held, might be justly described as that of low muttering delirium. One of the most striking proofs of the aberration of nervous and intellectual action is that the patient appears to be wholly insensible to his most distressing condition, — does not notice the horrible stench from his rotten arm, or from his fetid evacuations, and in reply to inquiries after his health, states that he is much better, and will be soon well. When, however, his arm is moved, his face is greatly contorted, he groans out, and weeps like a child.

Tongue dry, and of a dark purple and blue color. No appetite. Refuses food; or if he attempts to eat, takes a mouthful or two, and then says that he is satisfied. Skin dry, and rather harsh to the feeling.

Two o'clock P. M. Temperature of hand, 39° C. (102.2° F.). Temperature of axilla, 39.2° C. (102.6° F.). Pulse 100, very feeble, a mere thread. Respiration 21. Treatment, directed by the attendant medical officer, Assistant-Surgeon Powell, consists of tincture muriate of iron, m. xv., and sulphate of quinia, grains iii., three times a day; astringent pills of tannin and opium, every three hours, designed to control the bowels; turpentine emulsion, table-spoonful every four hours; and nutritious diet.

This day I made the sketch, Plate No. 9,[1] of the right arm of this patient, designed to give a general idea of the extent and color of the gangrenous wound. This represents the right arm bent as it rested upon a pillow. In making this drawing, I was seated upon the left side of the patient facing his head. The denuded bones were exposed upon the opposite side, and are not therefore represented in this sketch.

October 2. — Nine o'clock A. M. Speech low, and intellect sluggish. Left hand trembles continuously. Tongue trembles when protruded, and the muscles of the mouth tremble, as well as the balls of the eye when speaking. Voice tremulous, hesitating, and feeble. Still unconscious of his condition, and says that he is better. The muscles present the same glazed appearance, and red, purple, and green and bluish colors. The odor of the wound intolerable. Gangrene continues to spread, and is destroying the capsular ligament of the elbow joint. No pus is secreted by the denuded surface, nothing but a fetid, sanious, greenish, gangrenous, disorganized matter flows in small quantities from the wound. Tongue presents the same dry, dark purple, blue color. No appetite whatever. Bowels still running off, — discharges of a yellow

[1] Omitted.

color, with abundant evidence of bile. Stools emit a most disagreeable smell, similar to that of gangrenous matter, with the addition of a strong human fœcal smell.

Some hemorrhage from the wound this morning. Temperature of axilla, 38.5° C. (101.4° F.). Temperature of hand, 37.2° C. (99 F.). Pulse 100, very feeble. Respiration, 18. As the day advanced, the pulse became more rapid, and reached 120 at two P. M. The respiration also increased in frequency, and the temperature of the body rose several degrees. (Treatment continued.)

Examination of Urine. — Amount of urine collected during twenty-four hours (October 1, one o'clock P. M.), grains 5581.63; specific gravity, 1013. Deep orange-red color. The amount of urine collected does not represent the entire amount excreted, as it was impossible to collect a large portion of the urine on account of the incessant actions on the bowels. At the end of four days the urine still gave a strong acid reaction; and at this time a white scum floated upon the surface, which was found under the microscope to consist of numerous vegetable cells, resembling the Torula of diabetic urine; and the body of the fluid was turbid from the presence of thousands of these vegetable cells. A few casts of the tubuli urimferi were also observed. When first collected the urine was perfectly clear.

ANALYSIS OF URINE, NO. 8.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours (Oct. 1, one P. M., to Oct. 2, one P. M.,) only a small portion of the entire amount collected, on account of the affection of the bowels	5581.63	
Urea	177.87	21.11
Uric acid	2.45	0.43
Free acid	10.78	1.93
Phosphoric acid	16.60	2.97
Equivalent of phosphorus in phosphoric acid . . .	7.28	1.10
Sulphuric acid	5.16	0.92
Equivalent of sulphur in sulphuric acid	2.06	0.369
Chloride of sodium	5.39	0.96
Equivalent of chlorine in chloride of sodium . . .	3.55	0.63

October 3. — No improvement. At nine o'clock A. M., the pulse was very feeble and rapid, could scarcely be felt, and could not be counted with accuracy. Surface of hands very cool; patient very feeble and restless. As the day advanced, the temperature gradually rose, and the extremities became warm; and at 12 M., the temperature of the axilla was 39° C. (102.2° F.), and the temperature of the hand 38.2° C. (100.8° F.). Pulse 124, very feeble, and could scarcely be counted, but feebler than at nine A. M. Respiration, 24. Says that toward morning

he had felt completely chilled. Tongue inclined to be dry, slightly furred at the sides, but of a deep purplish and blue and leaden hue in the centre and around the edges. This color is very striking. Bowels very loose; operations exceedingly fetid. Still no suppuration from wound. Gangrene progressing. Patient very feeble, nervous, restless, and stupid; appears to be somewhat deaf.

Six o'clock P. M. Pulse, 120; very feeble. Respiration, 29. Temperature of hand, 38.2° C. (100.8° F.). Temperature of axilla, 39.2° C. (102.6° F.). Tongue of a bluish color and very dry. Patient continues in the same miserable state; he is, however, wholly unconscious of his true condition, and when aroused from his dull, stupid state, says that he feels somewhat better.

October 4. — Hemorrhage from the brachial artery, near where it divides into the ulnar and radial arteries, took place this morning at sunrise, and the patient died in twenty minutes. Although not more than one pint of blood was lost, the patient was so feeble that death was the result.

Examination of Blood. — The blood was preserved for examination and analysis. The blood presented a dark grumous appearance, and the surface changed very slowly to the arterial hue when exposed to the action of the atmosphere; and the scarlet, or rather the purplish-scarlet color, did not penetrate for any distance into the coagulum. In coagulating, the clot did not inclose all the colored blood corpuscles, and the serum presented a turbid red color. Many of the colored corpuscles settled to the bottom of the serum. No buffy coat was formed, and the clot resembled that of a case of malarial fever more nearly than the blood of the phlegmasiæ.

During the hemorrhage, seven hundred and seventy grains of blood were carefully received into a porcelain capsule, and from this I separated and determined the fibrin with great care, and found it to amount to three and one tenth (3.1) grains.

Fibrin, in 1,000 parts of blood, 4.02.

The structure of the clot was less firm than in health, or in inflammatory diseases of a sthenic character.

The arm was carefully examined after death, and the parts were found to be firmly contracted. In attempting to straighten the arm, the rotten muscles and tendons were ruptured. Gangrene had penetrated the joint, which contained fetid sanious, greenish, gangrenous fluid matter.

Commentary. — The question of amputation was one of most serious importance in this case. The arm should have been amputated immediately after the opening of the joint. This was the only chance for the salvation of this patient. This question will be more fully discussed hereafter under the head of treatment. In the present case, it was

Commentary. Question of amputation of serious importance.

thought advisable by the attendant physician to delay the operation until the constitutional symptoms were improved, and there were some evidences of the arrest of the progress of the gangrene.

In such cases, when any large joint is extensively denuded, exposed, and opened, amputation under almost any circumstances appears to be demanded, even though from the extent to which the general system has been involved the disease will certainly return in the stump; for we thus remove the large diseased painful source of infection, substituting a much smaller wound, and the danger of hemorrhage is, for a time at least, lessened.

The arm should have been amputated as soon as the joint was exposed.

The proper course of treatment in this case would have been to have amputated as soon as the joint was exposed and opened, and there was risk of hemorrhage; and then the patient should have been placed upon large doses of turpentine (m. xx. to f℥i. in form of emulsion every three or four hours), and alcoholic stimulants (whiskey or brandy, f℥ss. to f℥i. every two or three hours), and upon the most concentrated animal food and digestible vegetables; and the stump should have been kept scrupulously clean, and surrounded with cloths saturated with Labarraque's solution of chlorinated soda, and with tincture of camphor.

Signs of the action of the gangrenous poison upon the general system.

The action of the gangrenous poison upon the general system was manifested by the feeble, rapid action of the heart, the great changes of temperature, the depressed, enfeebled nervous and muscular forces, the trembling hands and the low muttering delirium, and the trembling eyeballs and quivering features, and the insensibility of the organs of sense, the derangement of digestion, and the fetid diarrhœa.

The dusky sallow hue of the complexion, and the livid blue color of the tongue, were manifestly due to derangements induced by the gangrenous poison in the constitution of the blood and in the capillary circulation, and in the processes of nutrition, secretion, and excretion. The blood appeared to have lost in great measure its power of absorbing oxygen. And were the processes of analysis sufficiently exact and comprehensive, it might have been possible to have detected the gangrenous poison or the products of its action in the blood. The intestinal canal appears to eliminate considerable quantities of the offending matters from the blood.

The fibrin of the blood was slightly increased

The fibrin was slightly increased above the standard of health, being 4.02 parts in 1,000 parts of blood; whilst in healthy blood the fibrin may vary from 2 to 3.5 in 1,000 parts,

it was below the standard observed in the phlegmasiæ generally; thus, according to Andral and Gavarret, the mean of fifty-eight analyses of the blood of pneumonia gave 7.3 parts of fibrin, with a minimum of 4, and a maximum of 10.5; in pleuritis, mean of five analyses, 6.1; in angina tonsillaris, mean of six analyses, 5.55; and according to Becquerel and Rodier, the standard for the phlegmasiæ generally, as determined by numerous observations, is 5.8. In this case the fibrin was increased above the standard usual in idiopathic fevers; thus, in nine cases of malarial fever I found the fibrin to range from 0.877 to 2.938, with a mean in 1,000 parts of blood of 2.018; in marsh cachexy, induced by the malarial poison, Becquerel and Rodier found in five cases the fibrin to range from 2.36 to 4.27, with a mean of 3.39; Andral and Gavarret, in forty-one analyses of the blood in typhoid fever, give the minimum of fibrin as 0.9, the maximum, 4.2, and the mean, 2.6; in typhus fever, according to M. H. Guenaud de Mussy and M. Rodier, maximum, 3.9, mean, 2.466, minimum, 1.2.

above the standard of health. Comparison of this result, with the proportion of this constituent in various diseases.

The fibrin was increased above the standard for small-pox, as determined by Andral and Gavarret (mean of blood of five cases of small-pox, 2.4, maximum, 4.4, minimum, 1.1); it was less than that of scarlatina, according to the same observers (mean of four cases, 4.35, maximum, 6.8, minimum, 3.1); it was somewhat greater than that of measles: mean of seven cases of measles (Andral and Gavarret), 2.742, minimum, 2.4, maximum, 3.4.

It is also important to note that this constituent of the blood was in larger amount than in acute or chronic scurvy; thus, according to Becquerel and Rodier, the fibrin in 1,000 parts of the blood of a man aged 48 years, sick with scurvy 42 days, was 2.5; in a man aged 21 years, sick 30 days, 2.2; in a man aged 32, sick 455 days, 1.85; in a man aged 23, sick 552 days, 1.32.

The fibrin in larger amount than in acute or chronic scurvy.

As far as my observations have extended, there is no necessary connection between hospital gangrene and scurvy. The two diseases may exist together, and hospital gangrene appears to commit most frightful ravages in scorbutic patients, but they are not related to each other as cause and effect.

No necessary connection between hospital gangrene and scurvy.

This observation is still further sustained by the fact that the remedies best adapted to the cure of scurvy exert little or no effect upon the progress of hospital gangrene, and I have seen hundreds of cases arising in men in whom no sign of scurvy was present.

When the two diseases exist in the same individual it is undoubtedly true that it is difficult to eradicate and cure the hospital gangrene until the scurvy has been removed by a proper course of treatment and diet; but this fact does not at all establish any identity or even relationship between the two diseases.

The fibrin was increased to a much less extent than is usual in erysipelas.

It is also worthy of consideration that the fibrin was increased to a much less extent than is usual in erysipelas; thus, Popp found this constituent to exist in the blood of a man suffering from erysipelas in as large a proportion as 6.6; and Andral and Gavarret, in eight analyses of the blood in this disease, determined the mean to be 5.676, minimum, 3.6, maximum, 7.3.

Some have supposed that hospital gangrene was intimately related to erysipelas; this fact, however, together with the absence of pus in the former, and the rapid and almost invariable and abundant formation of this result of the inflammatory process in the latter, demonstrates that the two diseases are distinct.

Finally, the results of the examination of the blood in this case sustain the observations recorded in the first pages of this chapter, and sustain the view that the essential conditions of inflammation are present in hospital gangrene.

Case XIII. Illustrating the changes of the blood in hospital gangrene.

Case XIII. J. M. Broom, private, Company A, 9th Mississippi Regiment. Age, twenty-eight. Occupation before entering the Confederate service, farming. Native of Mississippi. Wounded at Jonesboro', Georgia, September 2, 1864. Sent from the field of battle to the Floyd House Hospital in Macon, and was transferred from thence to the Empire Hospital, Vineville, on the 27th of September. Minie-ball passed through the muscles of the neck and shoulder above and almost parallel with the scapula.

Gangrene is said to have appeared in this wound about the 20th of September. The application of nitric acid, accompanied with the internal administration of quinine and tincture of chloride of iron, appeared to arrest the gangrene.

When I examined this case on the 30th of September, the wound on the left shoulder and side of neck was six inches in length by about three inches in breadth, extending from the median line of the neck to the acromio-clavicular articulation. The muscles of the neck were extensively denuded, and the clavicle was exposed throughout a considerable portion of its anterior surface. In the act of swallowing, the play of the muscles could be most distinctly seen and studied. The gangrene appeared to be arrested and removed, and the surface of the wound presented a bright red appearance, and in some parts granulations were forming, and some pus was secreted. The patient was able

to sit up, and was cheerful, with a good complexion, bright eye, excellent appetite, bowels regular, and little or no constitutional disturbance. The attendant physician affirmed that "the gangrene was all out, and the wound was healing rapidly."

October 1. — In the evening was seized with a chill, followed by fever.

October 2. — About six o'clock in the morning, hemorrhage took place from the wound in the neck. The hemorrhage was very slow, as if issuing from a vein, and the amount of blood lost was not more than one half-pint. The hemorrhage appeared to be almost immediately arrested upon the application of a strong solution of persulphate of iron to the wound. The patient, however, who was sitting up at the time of the occurrence of the hemorrhage, was immediately seized with great difficulty of breathing, loss of muscular power, irregular thumping action of the heart, and total cessation of the pulse; and he lay with eyes fixed, gasping for breath, unable to articulate, with cold, purple hands and lips, as if in articulo-mortis, and finally died in the afternoon, about eight hours after the hemorrhage.

Examination of Blood. — The coagulum was firm, and changed to a bright red color, with very nearly the same rapidity as in healthy blood.

Sixteen hundred and eight grains were carefully collected, which were employed for the determination of the fibrin. Upon careful analysis this quantity of blood yielded 9.7 grains of fibrin.

Fibrin in 1,000 parts of blood, 6.03.

Autopsy, Twelve Hours after Death. — The wound was first carefully explored. The external jugular vein had been completely destroyed by the gangrene. Notwithstanding the healthy appearance of those portions of the wound which were exposed to the naked eye during health, it was found that gangrene still existed in and around the cellular tissue surrounding the internal jugular vein, and that it had destroyed the anterior coats of this blood-vessel for the space of about the fourth of an inch in diameter. A firm coagulum of laminated fibrinous matter plugged up the vein almost completely beneath the point of erosion.

The jugular vein, both above and below the fibrinous laminated concretion, was distended with air. The fibrous formation did not appear to fill the vein sufficiently to prevent either the access of air or the escape of blood.

I carefully dissected out the carotid artery, and traced its trunk and branches; the descending into the arteria innominata and aorta, and the ascending trunk into the carotid foramen and into the muscles of the face. The carotid artery was carefully examined, therefore, far into the sound parts, both above and below the wound, but throughout, its coats were found to be sound and healthy. The gangrene had not invaded this vessel.

The clot in the internal jugular vein formed at the eroded and gangrenous part, did not appear to have been formed by the action of the

persulphate of iron, but appeared to have been the result of the gangrenous inflammation, for the concretion was almost entirely free of colored blood corpuscles, was firm and laminated and elastic in its texture, and was firmly attached to the walls of the vein. This was evidently the process by which veins are often obliterated by hospital gangrene, with little or no hemorrhage.

The right side of the heart was greatly distended. When the scalpel was plunged into the auricle, it collapsed just as a gut filled with air collapses when punctured, only more rapidly and completely. With this collapse there was an audible puff of air. The right ventricle was as much distended as the auricle, and both contained much frothy blood, as if the blood and air had been violently churned together.

The lungs were both healthy, and collapsed as usual in healthy lungs. I examined the apex of the left lung, which came quite up to the wound, but discovered no appearance whatever of gangrene or of inflammation. The costo-pleural cavity on the left side contained about f℥v. of bloody serous fluid.

Abdomen. — Liver, a little darker upon the anterior surface than usual; inferior surface of a slate color. When incisions were made through the slate-colored portions, the structures of the liver presented a bronze color for a few lines beneath the surface.

Spleen enlarged to three times its normal size and somewhat softened. This man had a chill fourteen hours before death.

Alimentary canal (stomach, duodenum, jejunum, ileum, colon, and rectum), healthy throughout its entire extent.

Commentary. — Death was caused in this case evidently from the entrance of air into the internal jugular vein through the erosion caused by the gangrene. Nature had (if we may use the expression) made great efforts to repair by a fibrinous clot the ravages of the gangrene, but had not been entirely successful.

Commentary. Death caused by the entrance of air into the internal jugular vein.

The fibrin, although the gangrene was rapidly disappearing, was above the normal standard.

Fibrin increased.

It is worthy of notice that the fibrin was more abundant in this case, in which there were little or no constitutional symptoms, than in the preceding case, where the blood had been evidently altered and poisoned by the virus and its products.

CASE XIV. William Martin, private, Company H, 3d Tennessee Regiment. Age, twenty-five. Height, five feet six inches. Weight in health, about one hundred and fifty-five. Light complexion, red hair, blue eyes. Entered Confederate service, May 1861. Has always enjoyed good health, both in and out of the army. Was wounded in the left hand at Raymond, Mis-

Case XIV. Illustrating the changes of the blood in hospital gangrene.

sissippi, 12th of May, 1862. This wound healed readily. Received his present wound on the 16th of August, 1864, at Atlanta. The minie-ball passed through the middle of the right fore-arm. The ulna was shattered, and the fractured fragments were resected in the field hospital. The day after the reception of this wound, the patient was sent from Atlanta to the Blind Asylum Hospital, Macon, where he remained ten days, and during this time gangrene appeared in the wound. Transferred to Empire Hospital, Vineville, on the 29th of August.

September 30. — Patient pale, anæmic, with hectic flush; little or no appetite; nervous and excitable. Pulse feeble and accelerated. Wound six inches in length, and two inches in width. The local application of nitric acid, together with the internal administration of muriate of iron and quinine, have been attended with marked improvement in the wound, portions of which look healthy, with florid granulations which are now secreting pus. The gangrene, however, is still present in the deeper portions of the wound, and especially along the track of the large blood-vessels. Extensive sloughing is going on around the elbow joint, and upon that portion of the fore-arm resting upon the pillow and subjected to pressure, and sinuses are forming in various places and discharging fetid pus; and it is evident that there are dead portions of bone still in the wound.

Considerable hemorrhage took place from the wound this day.

Examination of Blood. — The blood presented a dark color, which was slowly changed to the color of arterial blood by the action of the atmosphere. The clot was soft and large; serum clear; no buffy coat was formed.

One thousand grains of blood were carefully received during the hemorrhage into a porcelain capsule; this yielded two and one tenth grains of fibrin.

Fibrin, in 1,000 parts of blood, 2.1.

October 6. — The hemorrhage was arrested by applying the muriated tincture of iron (tinctura ferri sesquichloridi) directly to the bleeding surface, and applying compresses saturated with this strong styptic. Up to the present time the hemorrhage has not returned, and the wound presents rather a better appearance; the granulations are somewhat more numerous. The discharge of thin, offensive pus is, however, very great, and the sloughing is extending amongst the tissues subjected to pressure. The general system is seriously involved; hectic fever, with great nervous depression and restlessness.

October 9. — The arm was amputated near the middle. The structures were found to be extensively disorganized, and the bones necrosed.

October 25. — The flaps have not united, and the wound of the stump looks pale and flabby and swollen, and discharges a thin, aqueous, and fetid sanies. Flaps swollen and everted. Bone prominent, with marrow protruding. The end of the humerus as well as its protruding marrow is of a jet-black color.

Several gangrenous limbs were amputated about the same time in the Empire Hospital, and they all present very much the same appearance, — sallow anæmic complexions, with pale, flabby, swollen, ununited stumps, protruding bones, and fetid ichorous discharges.

October 29. — No improvement of the stump; wound pale, flabby, swollen, with thin, offensive discharge; bone protruded beyond the pale, unhealthy, grayish tissues; marrow of bone prominent and black. Flaps swollen, with everted edges; purplish areola around the edges of the wound, and extending up, encircling the arm, which is much swollen up to its junction with the trunk. Bright hectic flush upon the cheeks. Patient has a hot fever. Pulse 124, very feeble and flickering. Skin hot and dry and harsh to the feeling. No appetite. Bowels loose. The patient appears drowsy and stupid, and is evidently not in his right mind. Mutters to himself and answers incoherently, and resembles a man under the influence of a strong narcotic; he has, however, taken nothing of the kind. When aroused, the face expresses great anxiety and even horror, and the patient cries like a child when the stump is touched.

Large bed-sores are forming on the back, and hospital gangrene has commenced its ravages, and is rapidly denuding the muscles. There is a very bad gangrenous bed-sore over the right scapula on the same side with the amputated arm. Although the orifice in the skin of this bed-sore is not more than two inches in diameter, still the tissues are extensively destroyed beneath the apparently sound skin. Considerable portions of the dead tissues have been removed by the forceps. When a good light is thrown upon the orifice, we can look for a considerable distance within and under the edges of the orifice and see the gray, greenish, and bluish gangrenous tissues.

October 31. — Pulse 126, very feeble. Tongue red, cracked, and coated with sticky, clammy saliva, and flakes of whitish fur. Bright hectic flush upon cheeks. Skin hot and dry. Patient dull and stupid, and continues in the same low muttering delirium. Wound presents no improvement. Gangrene continuing its ravages both in the stump and in the bed-sores.

November 1. — Continues to grow worse. Had a chill, followed by fever. Eyes and complexion jaundiced.

During this day and night had several chills, and the complexion became still more deeply jaundiced as in pyæmia.

Early in the morning, November 2, hemorrhage took place from the arm, and the patient died.

Commentary. — In this case the profuse discharge of unhealthy sanious pus and ichorous gangrenous matter, and the grave constitutional disturbances, were attended with a decrease of fibrin below the standard of health.

Commentary. Fibrin decreased.

Case XV. Illustrating the characters of the blood in hospital gangrene.

Case XV. James House, private, Company K, 2d Mississippi Regiment, Jackson's Division. Native of Scott County, Mississippi. Age, sixteen. Height, five feet seven inches. Light brown hair; bluish gray eyes. Fair, freckled complexion. Mild, boyish expression of countenance. Has been in Confederate service since the 16th of April, 1864. Wounded on Flint River near Lovejoy's Station, 1st of August, 1864. This young soldier was retiring for ammunition, when a ball severed the tendo-achillis of the right leg and shattered the lower portion of the fibula, and passed out upon the anterior part of the ankle. Was transferred from the field of battle to Macon, and entered the Stout Hospital. After remaining there four or five days, gangrene made its appearance, and the patient was transferred to the Empire Hospital at Vineville. At this time was suffering from both gangrene and erysipelas. A portion of the fibula exfoliated; and the outer side of the right foot became gangrenous, and the destruction of tissue around the ankle, instep, and side of the foot was extensive. The usual local and constitutional treatment appeared to arrest the spread of the gangrene to a considerable degree, and healthy granulations sprang up in many portions of the wound, and pus was secreted in large quantities.

It was evident, however, that much dead bone remained, and that the great swelling of the leg, together with the profuse discharge of an unhealthy fetid pus and the formation of numerous sinuses, were due to necrosed bone, and that there was no chance for recovery but in amputation.

October 29. — Leg greatly swollen, and discharging large quantities of most offensive pus. The constitutional symptoms are pretty good. The appetite is fair, and the spirits excellent. All parts of the wound which can be examined by the naked eye present a bright florid appearance, with luxuriant granulations.

The pus discharged from the deeper portions of the wound resembled, in its horribly fetid odor, that which is so often discharged in and around necrosed bones, and mingled with the products of gangrenous tissues.

Amputation of the lower third of the thigh was performed upon the evening of this day.

Examination of Blood. — Blood changed slowly to arterial hue. Clot firm and well formed. No buffy coat. Serum clear. During the operation 1,137 grains of blood were carefully received into a porcelain capsule. Upon analysis, the fibrin in this quantity of blood amounted to three and thirty-six hundredths grains.

Fibrin in 1,000 parts of blood = grains 3.04.

November 5. — After the operation the stump swelled greatly, and fever set in. The leg was dissected after amputation, and the bones in the region of the ankle joint, and especially the fractured fibula, were

extensively necrosed, and portions of gangrenous tissue were found in the lower part of the leg, and the pus had burrowed amongst the muscles extensively. At the present time, November 5th, pulse, 120; skin hot and dry; hectic flush on cheek; pale anæmic countenance. Patient very nervous; cries like a child when even the proposition to look at his thigh is made. Stump much swollen; it is at least three times the size of the other sound thigh, which is greatly emaciated. Edges of flaps swollen and everted and widely separated, and bone protruding more than one inch beyond the swollen tissues. The marrow of the bone protrudes, and is of a black color. But little pus discharged from the wound, but in its stead a thin, unhealthy sanies.

November 9.— Some improvement in the stump; swelling subsiding, and a little pus secreted. My observations upon this case did not extend beyond this date. At this time the chances of this patient were slim indeed.

Commentary. — The fibrin in this case was neither increased nor diminished; that is, it was within the limits of health, as far as its quantity was concerned. In so extensive an inflammation of the structures of the leg as this patient was laboring under, we would naturally look for an increase of the fibrous element of the blood. We are justified by the whole history of this case in believing that there was some cause or combination of causes which hindered the increase of fibrine usual in such cases of inflammation.

Commentary. Fibrin normal in amount.

The profuse discharge from the affected limb, as well as the absorption of the products of the disorganized tissues, may have had much to do with restraining the increase of the fibrinous element of the blood.

Case XVI. John F. Kelly, private, Company A, 26th Alabama Regiment, Conley's Brigade, Walthall's Division. Native of Alabama. Age, twenty-five. Height, five feet ten inches. Weight in health, one hundred and sixty pounds. Brown hair, brown eyes. Wounded on the 28th of July, 1864, at Atlanta; the musket-ball passed through the right foot, from the middle toe to the heel. A number of fragments of bone were taken out by the field surgeon. Was sent from Atlanta direct to the Stout Hospital, in Macon, and remained three weeks before gangrene attacked the wound. The patient says that he had a severe attack of fever before the gangrene appeared, and the fever continued for three weeks, during which time there was much delirium.

Case XVI. Illustrating the composition of the blood in hospital gangrene.

Gangrene made extensive ravages amongst the tendons and bones of the foot, and penetrated the ankle joint.

Transferred to the Empire Hospital, 21st of August. The external

portions of the wound improved under treatment, but the carious bones excited a continuous fetid discharge, and so continuous was the loss of tissue and exhaustion of strength, that amputation was resorted to as the only means of preserving life.

The leg was amputated just below the knee joint, on the 18th of October, by Assistant-Surgeon Powell.

The bones were necrosed in various places, and the gangrene was still present in the deep-seated tissues.

Examination of Blood. — Blood coagulated firmly. No buffy coat. Serum clear. The clot changed slowly to the arterial hue, upon exposure to the atmosphere, and the color of the surface was darker and more purplish than in health.

Six hundred and twenty grains of blood were carefully preserved for analysis. The fibrin in this quantity of blood amounted to two grains and fifty-five hundredths.

Fibrin in 1,000 parts of blood, 4.11.

October 21. — The wound looks pale, and the edges are swollen. The stump discharges pus of a disagreeable odor. Patient pale, anæmic. Pulse 120, feeble. Tongue clean and natural. Bowels running off. Had four actions during the past twenty-four hours. Nervous system depressed, and in an irritable state.

October 25. — Appears to be better. Has but little fever. The wound discharges pus. Little or no union has taken place between the surfaces of the flaps. The edges of the flaps look pale and swollen. Complexion of patient pale and anæmic. Spirits better, and appetite improved.

October 29. — Twelve o'clock M. At this time the patient is vomiting; the vomiting appeared to be due to some casual derangement of digestion, and was very different from that vomiting of green bilious matter which is so fatal a sign in these cases of ill-conditioned and gangrenous wounds. Appetite has been quite good. Wound looks pale, and discharges a thin pus. There appears to be some union at the lower and upper portions of the flap. Pulse, 94. Skin cool. Tongue clean. Complains of a small pimple on the neck of his penis, which gives much pain, especially during micturition. Several small bedsores have formed upon his back.

November 5. — Doing well. Wound healing. Discharges quite healthy in appearance. Appetite good. Spirits excellent. Complexion clear; and eye clear and bright, with cheerful expression of countenance.

November 10. — Continues to improve.

Commentary. — The fibrin in this case was increased somewhat above the standard of health, but was below that of the phlegmasiæ.

Commentary. Fibrin slightly increased.

We will proceed in the next place to examine the collective results of these observations upon the changes of the blood in hospital gangrene.

In the final report, we hope to be able to present complete analyses of all the constituents of the blood in this disease.

Importance of the determination of the amounts of fibrin.

The determination of the variations of the fibrin appears to be of the first importance, because of the relations which the quantitative and qualitative changes of this constituent of the blood bear to the phenomena of the two great classes of disease, the phlegmasiæ and the pyrexiæ.

Grounds for the establishment of the true theory of hospital gangrene.

The true theory of hospital gangrene, as well as of all other diseases, must be based not merely upon the outward manifestations or symptoms, but also upon the more intricate and complicated changes in the constitution, and qualitative and quantitative relations of the individual constituents of the blood and tissues, and of the secretions and excretions. However imperfect the present labors may be, we feel, however, that they are at least in the right direction, and that this method of investigating diseases, when perfected and applied to those subjects which are capable of successful investigation, will ultimately lead to the discovery of those facts upon which the true theory and classification of diseases should rest.

We have drawn up the following table of the proportions of fibrin in various diseases, that we may be able, as far as this constituent of the blood is concerned, to determine whether hospital gangrene should be classed with the phlegmasiæ or with the pyrexiæ.

TABLE OF THE FIBRIN IN 1,000 PARTS OF HEALTHY AND DISEASED BLOOD.

Observers.	Diseases.	Remarks.	
Andral et Gavarret / Becquerel et Rodier	Standard of health	In healthy blood the fibrin may vary	from 2.00 to 3.50
Joseph Jones	Hospital gangrene	Mean of five cases	2.86
Joseph Jones	Hospital gangrene	Maximum	6.03
Joseph Jones	Hospital gangrene	Minimum	2.10
Joseph Jones	Hospital gangrene	Case XI.	4.02
Joseph Jones	Hospital gangrene	Case XII.	6.03
Joseph Jones	Hospital gangrene	Case XIII.	2.10
Joseph Jones	Hospital gangrene	Case XIV.	2.04
Joseph Jones	Hospital gangrene	Case XV.	4.11
Becquerel et Rodier	Phlegmasiæ generally	Mean of numerous observat'ns	5.80
Becquerel et Rodier	Pneumonia	Mean of 1st bleedings	7.40
Becquerel et Rodier	Pneumonia	Mean of 2d bleedings	6.80
Andral et Gavarret	Pneumonia	Mean of fifty-eight analyses	7.20
Andral et Gavarret	Pneumonia	Maximum of ditto	10.50
Andral et Gavarret	Pneumonia	Minimum of ditto	4.00
Andral et Gavarret	Pleuritis	Mean	4.65
Andral et Gavarret	Pleuritis	Maximum	5.90
Andral et Gavarret	Pleuritis	Minimum	3.80
Becquerel et Rodier	Pleuritis	Mean of five cases	6.10

TABLE OF THE FIBRIN IN 1,000 PARTS OF HEALTHY AND DISEASED BLOOD.—(*Continued.*)

Observers.	Diseases.	Remarks.	
Becquerel et Rodier	Acute bronchitis	Mean of four cases	4.80
Andral et Gavarret	Acute bronchitis	Maximum of six cases	9.20
Andral et Gavarret	Acute bronchitis	Mean of ditto	5.70
Andral et Gavarret	Angina tonsillaris	Mean of six cases	5.55
Andral et Gavarret	Angina tonsillaris	Maximum of ditto	7.20
Andral et Gavarret	Angina tonsillaris	Minimum	3.80
Andral et Gavarret	Acute rheumatism	Mean of forty-three cases	6.70
Andral et Gavarret	Acute rheumatism	Maximum of ditto	10.20
Andral et Gavarret	Acute rheumatism	Minimum	2.80
Andral et Gavarret	Chronic rheumatism	Mean of ten cases	3.80
Becquerel et Rodier	Articular rheumatism	Mean	5.80
Becquerel et Rodier	Puerperal fever	Mean of four cases	6.76
Heller	Puerperal fever		5.16
Popp	Febrile arthritic rheumatism	Female aged 20, 1st bleeding	11.89
Popp	Febrile arthritic rheumatism	Female aged 20, 2d bleeding	12.97
Popp	Febrile arthritic rheumatism	Male aged 22, 1st bleeding	11.40
Popp	Febrile arthritic rheumatism	Male aged 22, 2d bleeding	7.91
Popp	Febrile arthritic rheumatism	Male aged 22, 3d bleeding	9.25
Popp	Febrile arthritic rheumatism	Female aged 20	13.34
Popp	Glanders	Female aged 20	6.37
Popp	Glanders	Female aged 20	10.48
Popp	Inflammation of brain	Female aged 20	8.40
Popp	Inflammation of brain	Female aged 20	6.30
Popp	Erysipelas	Man aged 33 years	6.60
Andral et Gavarret	Erysipelas	Mean of eight analyses	5.67
Andral et Gavarret	Erysipelas	Maximum of ditto	7.30
Andral et Gavarret	Erysipelas	Minimum of ditto	3.60
Andral et Gavarret	Phthisis	Mean of twenty-one cases	4.40
Andral et Gavarret	Phthisis	Maximum of ditto	5.90
Andral et Gavarret	Phthisis	Minimum of ditto	2.10
Becquerel et Rodier	Phthisis	Mean of sixteen cases	4.80
Glover	Scrofula	Mean of eight cases, males	3.13
Heller	Carcinoma	Mean of seven cases	6.58
Heller	Carcinoma	Maximum of ditto	10.44
Heller	Carcinoma	Minimum of ditto	3.30
Wittstock	Cholera	One case	11.00
Simon	Cholera	One case	11.00
Becquerel et Rodier	Cholera	Man, day of death	1.88
Becquerel et Rodier	Cholera	Man, day of death	6.50
Becquerel et Rodier	Bright's disease, acute	Mean of fifteen cases	2.99
Becquerel et Rodier	Bright's disease, chronic	Mean of thirteen cases	4.34
Becquerel et Rodier	Chlorosis	Mean of six cases	4.20
Becquerel et Rodier	Anæmia	Mean of ten cases	3.72
Joseph Jones	Diabetes mellitus		2.80
Becquerel et Rodier	Acute scurvy	Man aged 48 years, sick 42 days	2.50
Becquerel et Rodier	Acute scurvy	Man aged 21 years, sick 30 days	2.20
Becquerel et Rodier	Chronic scurvy	Man aged 32 yrs., sick 455 days	1.85
Becquerel et Rodier	Chronic scurvy	Man aged 23 yrs., sick 552 days	1.52
Andral et Gavarret	Small-pox	Mean of five cases	2.40
Andral et Gavarret	Small-pox	Maximum of ditto	4.40
Andral et Gavarret	Small-pox	Minimum of ditto	1.10
Andral et Gavarret	Scarlatina	Mean of four cases	4.85
Andral et Gavarret	Measles	Mean of seven cases	2.74
Joseph Jones	Malarial fever	Mean of nine cases	2.01
Joseph Jones	Malarial fever	Maximum of ditto	2.98
Joseph Jones	Malarial fever	Minimum of ditto	0.87
Joseph Jones	Malarial fever	Intermittent fever of 12 days	1.90
Joseph Jones	Malarial fever	Intermittent fever of 5 weeks	2.54
Joseph Jones	Malarial fever	Intermittent fever of 6 weeks	1.92
Joseph Jones	Malarial fever	Remittent fever of 16 days	2.98
Joseph Jones	Malarial fever	Remittent fever of 10 days	1.43
Joseph Jones	Malarial fever	Remit. and typhoid fever 11 d's	2.28
Joseph Jones	Malarial fever	Remittent fever 2 weeks	2.71
Joseph Jones	Malarial fever	Congestive fever	0.87
Joseph Jones	Malarial fever	Congestive fever	1.45
Andral et Gavarret	Typhoid fever	Mean of forty-one analyses	2.60
Andral et Gavarret	Typhoid fever	Maximum of seven ditto	4.20
Andral et Gavarret	Typhoid fever	Minimum of seven ditto	0.90
M. H. Guenand de Mussy et M. Rodier	Typhus fever	Mean of six cases	2.40
M. H. Guenand de Mussy et M. Rodier	Typhus fever	Maximum of ditto	3.90
M. H. Guenand de Mussy et M. Rodier	Typhus fever	Minimum of ditto	1.20

As far as the observations recorded in the preceding table extend, the fibrin of the blood is increased somewhat above the standard of health in hospital gangrene, whilst in this disease it is less than in the phlegmasiæ generally, but more abundant than in the pyrexiæ.

From the observations recorded in this and in the preceding chapter, and especially from the results of the microscopical and chemical examination of the gangrenous matter, and of the pus secreted by wounds after the removal of hospital gangrene, and the changes of the blood in this disease, the following conclusions may be drawn: —

1. Hospital gangrene is caused by the action of an irritant, corrosive, organic poison, generated during the decomposition of animal matter under certain conditions, and capable of exciting change and decomposition in living structures with which it is brought into contact, after the manner of a ferment.

1. Hospital gangrene caused by an irritant, corrosive, organic poison.

2. This poison may arise *de novo* whenever certain conditions favorable to its development exist.

2. The poison may arise *de novo*.

The most important of these conditions are, crowding together of sick and wounded soldiers in imperfectly ventilated and filthy hospitals, in which there is an insufficient supply of utensils, bandages and lint, and instruments; and transportation of large numbers of wounded soldiers in close box-cars, without any cleansing of their filthy, offensive wounds. Bad diet, previous exposure, and crowding of soldiers into confined spaces during sieges, and in filthy camps, with defective police, and with the air contaminated with unburied fæces, induce such states of the system as are favorable to the development of hospital gangrene upon the reception of wounds.

3. Hospital gangrene may be both local and constitutional in its origin.

3. The disease may be both local and constitutional in its origin.

Animal matter, in a certain state of decomposition, is capable of acting upon a wounded surface, and of developing gangrenous inflammation; or the system may be so depressed by the action of gases and foul air inhaled, and by previous exposure and diet, that this form of inflammation may result from the depression of the forces, the derangement of nutrition, and the consequent degeneration of wounded parts. If the disease arise locally, the absorption of the gangrenous matter commences as soon as it is applied to any wounded surface, and goes on continuously as long as any gangrene is present, and the decomposing matters entering the blood derange its composition and the nutri-

tion of the body, and depress the forces. In this way the constitutional derangements may be manifested before the local changes are evident to the senses, without at all standing in the relation of cause and effect.

The admission of its local and constitutional characters at the same time, is not at all contradicted by the fact that we may have in the same patient one gangrenous wound and another entirely free from the disease. Neither does it follow that because the absorbed matters disturb the nutrition and composition of the blood and derange to a certain extent the forces, therefore amputation will not arrest the disease. Whether or not the severing of the gangrenous mass from the body will arrest the disease, will depend, not upon the mere fact of the absorption of the gangrenous matter, but upon the extent to which it has deranged nutrition and depressed the forces. Thus, the poison of the rattlesnake produces death of the immediate parts into which it is injected, and at the same time that portion which is absorbed alters the blood, acts upon the heart, deranges the nutrition, disturbs the circulation and respiration, and depresses the nervous and muscular systems. If the limb poisoned and rendered gangrenous by the action of the poison of the rattlesnake be amputated in the sound parts, it does not follow that because the constitution has been affected by the poison absorbed, that therefore the stump must also become gangrenous. Neither does it follow that because the gangrene was not reproduced in the stump, therefore the poison of the rattlesnake did not act constitutionally. In case of amputation for a gangrenous wound, the reappearance of the gangrene in the stump will depend on the amount of the matter absorbed from the local source and the extent to which it has deranged the system, and also upon the previous condition of the solids and fluids, and of the forces, before the reception of the infection.

4. The action of the poison of hospital gangrene is attended with both local and constitutional symptoms of inflammation.

4. The action of the poison of hospital gangrene attended with both local and constitutional symptoms of inflammation.

Thus, within the focus of active change and disintegration, there are alterations in the healthy structure and function of the affected parts, as indicated by the change of color and structure, the fetid odor, and the suspension of secretion and healthy nutrition by the altered condition of the blood, as manifested in the surrounding dark livid areola, by passive hemorrhages, and by the rapid decomposition of this fluid; and around the focus of active disintegration there is active deter-

mination of blood, congestion of the capillary blood-vessels, accumulation and stagnation of the colored blood corpuscles, relative and absolute increase of fibrin, albumen, and colorless corpuscles, effusion of coagulable lymph, and redness, heat, swelling, and pain. In the general system there is increase of fibrin in the blood, and more or less febrile disturbance, as manifested in the accelerated circulation, increased temperature, and deranged muscular and nervous actions.

5. The changes excited both locally and constitutionally by the gangrenous poison, are such that the products and phenomena of the disease vary to a certain extent from those of ordinary inflammations.

5. The phenomena of the disease vary to a certain extent from those of ordinary inflammations.

Thus, in hospital gangrene the lymph effused around the focus of disease possesses the power of coagulation and development into tissue, and there appears to be all the conditions necessary for the arrest of the disease by the development of coagulable lymph through nucleated cells into the fibrous and fibro-cellular or connective tissue; but the characters of the irritant poison are such that the products of inflammation, together with the blood-vessels and the blood itself, are rapidly disintegrated, the life of the blood is destroyed by the gangrenous poison, and the fluids and living organizable matter and cells, upon which the progress of inflammation depends, are poisoned. It results from this that the liquor sanguinis effused within the diseased structures does not pass into the stage of pus, as in healthy wounds, and in the common furuncle and carbuncle, or even in erysipelas and the pustules of small-pox, and the exudation corpuscles are so poisoned and disorganized that they are not further changed in either a progressive or descending series, and wherever the limiting fibrous wall is thrown out, with its organizable cell elements, it is in like manner destroyed when it is reached by the poison.

All the changes of the blood characteristic of ordinary inflammation may be present around the gangrenous part, as the increase of liquor sanguinis, with increase of its albumen and fibrin, both actually and relatively to the blood corpuscles, aggregation of the red corpuscles, and increase of the colorless and lymph corpuscles, but no arrest of the disease will take place as long as the poison is capable of exciting rapid change and decomposition, after the manner of a nitrogenized ferment in the products of inflammation.

6. The gangrenous poison and its

6. The gangrenous poison, as well as the compounds resulting from the disintegration which it induces in the

organic constituents of the structures, when absorbed, act as poisons upon the muscular and nervous systems, and tend to disorganize the blood and derange the actions of the alimentary canal.

products, after absorption, act as poisons upon the muscular and nervous systems, and disorganise the blood.

When absorbed in large quantities, these products frequently act as irritants to the intestinal canal, by which they are eliminated, and patients are sometimes destroyed by the diarrhœa consequent upon this action upon the intestinal mucous membrane.

The absorption and consequent action of the gangrenous poison upon the general system is manifested by the feeble, rapid action of the heart, the marked elevations and depressions of temperature, the depressed, enfeebled nervous and muscular forces, the trembling hands, the low muttering delirium, the trembling eyeballs and quivering features, the insensibility of the organs of sense, and by the derangement of digestion, and the fetid diarrhœa.

The derangements induced by the gangrenous poison in the constituents of the blood and in the capillary circulation, are manifested by the dusky, sallow, livid, and leaden hue of the complexion, the livid blue color of the tongue, the derangements of nutrition, secretion, and excretion, the diminution of the power in the colored corpuscles to absorb oxygen from the atmosphere, and by the partial increase of the fibrin, notwithstanding the presence of an inflammatory state.

It appears, therefore, that the fibrin is not increased in hospital gangrene to the extent usual in ordinary inflammations, on account of the absorption and action in the blood of the poison producing the disease, and of the products of the decompositions which it excites in the structures and fluids of the living animal. A similar condition is observed in the action of the poison producing small-pox. In this disease, also, as will be seen from the preceding table, notwithstanding the presence of both local and constitutional symptoms of inflammation, the fibrin is less than in uncomplicated inflammations, as in pneumonia.

CHAPTER THIRD.

Variations of the Temperature and Circulation in Hospital Gangrene. — Marked Daily Variations of the Temperature, also Marked Variations between the Temperature of the Trunk and Extremities. — Daily Variations of the Pulse. — The Observations upon the Variations of the Pulse and Temperature, of Importance in their Bearing upon the Nature and Treatment of this Disease. — Hospital Gangrene is especially characterized by the Great Difference which frequently exists between the Temperature of the Central Organs and that of the Extremities. — Whilst the Trunk presents the Heat of a Warm Fever, the Extremities will in many Cases feel cold, and in Fact the Temperature be not higher in Degree than that of a Regular Chill. — The Symptoms of Open Sthenic Inflammation are in general wanting in this Disease. — As a General Rule, the Respiration in Cases of Ordinary Severity is not disturbed to any Great Extent either in Character or Frequency; in this Respect the Febrile Excitement of Hospital Gangrene presents a Marked Difference from that of Malarial Fever. — Changes of the Urine in Hospital Gangrene. — Increase of Coloring Matters, of Urea and Uric Acid, Free Acid, Phosphoric and Sulphuric Acids. — Decrease of Chloride of Sodium. — When Pyæmia supervenes upon Hospital Gangrene, the Urine assumes a most beautiful Pink Color, from the Great Destruction of the Colored Blood Corpuscles, induced by the Presence of Pus in the Blood. — Cases illustrating the Changes of the Temperature, Circulation, and Urine, in Hospital Gangrene.

Changes of the temperature in hospital gangrene.

THE temperature is subject to marked periodical variations, as well as to great differences between that of the central organs and of the extremities. In hospital gangrene a marked diminution of the frequency of the pulse, as well as a decrease in the degree of animal temperature, almost invariably occur in the morning. As the day advances, the pulse increases in frequency, and the temperature progressively rises, and often attains a degree equal to that of a hot fever. The febrile excitement continues to increase, or remains stationary until near midnight, or until some refreshing sleep has been obtained, and then progressively declines, and reaches its lowest point about the period of waking in the morning. Thus the pulse in severe cases will frequently vary during the twenty-four hours twenty beats and over, and the temperature of the trunk will frequently rise from 99° F. in the morning to 104° F. in the afternoon and evening.

Hospital gangrene is especially characterized by the great difference which frequently exists between the temperature of the central organs and that of the extremities. I have frequently observed the temperature of the hands from ten to fifteen degrees below that of the head and trunk. Whilst the trunk presents the heat of a warm fever, the extremities will in many cases feel cold, and in

fact the temperature be not higher in degree than that of a regular chill.

This observation is of moment in the light which it throws upon the nature of this disease, and in the indications which it affords for treatment. It is evident that whilst the nervous and circulatory systems are excited in this disease, the excitement is limited by the enfeebled condition of the system, and manifests itself in feeble, irritative, irregular forms of action.

The symptoms of open sthenic inflammation are in general wanting in this disease.

As a general rule, the respiration in cases of ordinary severity is not disturbed to any great extent either in character or in frequency. In this respect the febrile excitement of hospital gangrene presents a marked difference from that of malarial fever.

CHANGES OF THE URINE IN HOSPITAL GANGRENE.

The coloring matters are increased, and the height of the color of the urine corresponds with the severity of the gangrene and the extent of the constitutional disturbances. Changes of the urine in hospital gangrene. Color.

In light cases, the urine approaches both in color and in chemical constitution to the urine of health. The color of the urine in this disease resembles most nearly that of typhoid fever.

When pyæmia supervenes upon hospital gangrene, the urine assumes a most beautiful pink color, from the great destruction of the colored blood corpuscles, induced by the presence of pus in the blood, the coloring matter of the blood resulting from the disintegration of the colored blood corpuscles being eliminated by the kidneys. Characteristic color of the urine in pyæmia.

In the urine of hospital gangrene we find such changes as characterize the increased physical and chemical changes of the febrile state.

Thus the urea and phosphoric and sulphuric acids are increased, but to a much less comparative extent than in the true fevers, as for example in typhoid fever. This difference is without doubt due to the depressed state of the system in hospital gangrene, as induced by the action of a special poison upon the blood, and upon the nervous and muscular systems. As in other forms of disease the extent of the destruction of the living tissues, as measured by the amounts of urea and phosphoric and sulphuric acids excreted by the kidneys, is proportional to the severity of the constitutional symptoms. Urea, phosphoric acid, and sulphuric acid.

Chloride of sodium.

The chloride of sodium is diminished, and in the severest cases disappears almost entirely. Diminutions in the amount, and variations of the characters of the nutriment, without doubt, have much to do with the diminution of this constituent of the urine; this fact, however, is of interest, as similar changes in the amounts of the chloride of sodium in the urine have been observed in various diseases, as pneumonia, small-pox, and typhoid fever.

Uric acid.

In most cases, the uric acid is greatly increased. The same fact is noticed in typhus and typhoid fevers, and in the depressed state of the system following malarial fever.

CASES ILLUSTRATING THE CHANGES OF THE TEMPERATURE, CIRCULATION, AND URINE IN HOSPITAL GANGRENE.

Case XVII. Illustrating the changes of the temperature and urine in hospital gangrene.

CASE XVII. Edward I. Wainwright, private, Company B, 1st Florida Cavalry. Age, twenty-eight. Height, five feet nine inches. Weight in health, one hundred and seventy-five pounds. Occupation before entering the Confederate army, farming. Native of Nassau, Florida. Entered service 15th of October, 1861. Says that previous to entering the army, he has always been strong and healthy. His mother, who was with this patient during my inquiries, affirmed that he had never been seriously sick since his birth. Was wounded on the 19th of September, at Chickamauga, by a piece of shell, which imbedded itself in the left buttock, about the middle of the glutæus maximus. The fragment of iron was taken out by the surgeon on the field. Was sent to the division hospital near the field of battle, and remained there until the next day, when he was transferred to Ringgold, Georgia. At this place he remained two days at the depot, receiving little or no attendance during this time, his wound not being dressed or receiving any attention. Was transferred from Ringgold to Atlanta, where he remained in hospital a few days, and was then sent to Augusta. After arriving in Augusta, remained at the railroad depot from 1 o'clock A. M. to 6 o'clock P. M., and was then, with a number of other wounded soldiers from the same battle-field, transferred to the Presbyterian Church. Two hundred and seventy-five wounded men were crowded into this building, which was only capable, according to the official regulations in cubic feet, of accommodating one hundred and twenty-five; and they were simply placed in the pews, a plank being placed so as to connect the seat with the side of the pew. In these badly-ventilated boxes the wounded lay. The windows of the church are elevated above the pews, and from their structure did not admit of free ventilation. In addition to this, the church was surrounded by a thick growth of trees. This patient remained in the Presbyterian Church three days, and was then trans-

ferred to the Second Georgia Hospital, on Broad Street, and walked there on crutches, the distance being not more than two hundred yards. At the time of his admission into the Second Georgia Hospital, his general health was good, and he presented the appearance of a strong, healthy man. The hygienic condition of this hospital does not appear to have been much better than that of the Presbyterian Church on Telfair Street.

On the 6th of October his wound became very painful and red, and he had high fever, accompanied with loss of appetite, low spirits, and depression of the muscular and nervous forces, and thirst. Had no chill, and his fever, although changing in severity at different periods of the day and night, did not go off with a sweat. Quinine was freely administered, but it produced no perceptible abatement of the febrile symptoms, although it caused ringing in the ears and deafness.

The wound was so painful that the patient was unable to sleep at night. On the following day after the fever, the wound showed marks of gangrene, and the disease spread with considerable rapidity.

November 2. — Complexion of an unhealthy, leaden hue. Pulse frequent, and rather feeble. Respiration natural. The wound on the buttock is oval, and about five inches in diameter, and over one inch in depth, with swollen, everted edges. The gangrene is still progressing in portions of the wound, whilst healthy granulations are to be seen in a few spots, which now secrete a little pus. The granulations, however, are not abundant, and they are paler than in a healthy wound. Appetite poor. Expression of eye dull and anxious. Spirits depressed.

November 3. — Symptoms much the same.

Examination of Urine. — Amount of urine passed during twenty-four hours, November 2, 1 P. M., to November 3, 1 P. M., 1,220 CC. = grains 19,507.30. Specific gravity, 1,016. Orange-red color. (See figure.[1]) Clear when first passed. At the end of thirty hours slight deposit of large, well-formed, highly colored, lozenge-shaped crystals of uric acid.

ANALYSIS OF URINE, NO. 9.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	19,507.30	
Urea	526.06	26.45
Uric acid	13.82	0.70
Free acid (30 hrs. after collection, and in warm weather)	16.90	0.86
Phosphoric acid	43.58	7.36
Equivalent of phosphorus in phosphoric acid . . .	19.13	0.98
Sulphuric acid	32.22	1.65
Equivalent of sulphur in sulphuric acid	12.88	0.66
Chloride of sodium	140.91	7.22
Equivalent of chlorine in chloride of sodium . . .	85.39	4.37

[1] Omitted.

November 6. — Nine o'clock A. M. Pulse 80, and feeble. Respiration, 16. Bowels constipated. Skin moist and warm. Wound somewhat diminished in size, and granulating, except along the upper border, which is filled with a humid slough. Temperature of hand, 31.1° C. (88° F.). Temperature of axilla, 36.4° C. (97.5° F.). Treatment consists of tincture muriate of iron, gtts. x., and chlorate of potassa, grs. v., three times a day. Local treatment of wound, saturated solution of sulphate of copper. Lint saturated with this was stuffed into the wound.

Nine o'clock P. M. Pulse 98, moderately full. Respiration, 18. Temperature of hand, 38.4° C. (101.1° F.). Temperature of axilla, 39.2° C. (102.5 F.). Tongue red at tip and centre; clear at tip and edges; slight coating of light white fur in two lines on either side of centre. Complexion of an unhealthy, leaden hue. Spirits depressed. Gangrene still progressing.

November 6. — Nine o'clock A. M. Pulse 86, and full. Respiration, 18. Skin warm and dry. Tongue cleaner and moister. Wound presents very much the same condition. Treatment and diet continued.

Five o'clock P. M. Pulse 96, and full. Respiration, 18. Temperature of hand, 36.2° C. (97.1° F.). Temperature of axilla, 37.4° C. (99.3° F.).

November 8. — Nine o'clock A. M. Pulse 80, and full. Respiration, 18. Tongue clean and moist. Skin warm and dry. Bowels constipated. Wound looks better; granulations increasing in number and extent. Temperature of hand, 31.2° C. (88.1° F.). Temperature of axilla, 37.2° C. (98.9° F.). Treatment and diet continued.

November 9. — Nine and one half o'clock A. M. Pulse 80, and full. Respiration, 18. Tongue cleaner and moist. Skin warm and dry. Temperature of hand, 32.2° C. (89.9° F.). Temperature of axilla, 36° C. (96.8° F.). Cool, frosty morning. Wound still improving. Treatment, and nutritious diet of beef and chicken soup and soft boiled eggs, etc., continued.

Eight o'clock P. M. Pulse 88, and full. Temperature of hand, 29.2° C. (84° F.). Temperature of axilla, 37.3° C. (99.1 F.).

November 10. — Continues to improve. Temperature, pulse, and respiration about the same as at this time yesterday morning.

Examination of Urine. — Deep orange color, inclining to red, but lighter than in the preceding examination. Amount of urine collected during twenty-four hours, 1,140 CC. = grains 18,270.00. Specific gravity, 1,015. Urine clear, and without deposit, when first passed.

The color of the urine is represented in Figure 1, Plate X.[1]

The appetite of this patient is moderately good, and as he is allowed a nutritious diet, the chloride of sodium exists in considerable amount in his urine, as will be seen by the following analysis: —

[1] Omitted.

ANALYSIS OF URINE, NO. 10.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	18,270.00	
Urea	395.01	21.07
Uric acid	15.30	0.83
Free acid (three hours after collection)	30.72	1.68
Phosphoric acid	39.32	2.15
Equivalent of phosphorus in phosphoric acid	17.25	0.94
Sulphuric acid	16.82	0.92
Equivalent of sulphur in sulphuric acid	6.72	0.36
Chloride of sodium	108.84	5.95
Equivalent of chlorine in chloride of sodium	65.95	3.62

November 15. — Continues to improve. Wound, as well as the general health, greatly improved. The gangrene has entirely disappeared. No febrile excitement during the day. Skin cool and pleasant. Complexion clear. Countenance bright and cheerful.

Examination of Urine. — Amount of urine passed during twenty-four hours, November 14, 9 A. M., to November 15, 9 A. M., 1,210 CC. = grains 19,373.85. Specific gravity, 1,017. Light orange color, nearly normal. (See Plate X., Figure 2.[1]) No deposit after standing ten hours.

ANALYSIS OF URINE, NO. 11.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during twenty-four hours	19,373.85	
Urea	372.68	19.23
Uric acid	12.38	0.63
Free acid (five hours after collection)	11.18	0.57
Phosphoric acid	25.33	1.30
Equivalent of phosphorus in phosphoric acid	11.11	0.57
Sulphuric acid	17.01	0.88
Equivalent of sulphur in sulphuric acid	6.80	0.35
Chloride of sodium	214.29	11.06
Equivalent of chlorine in chloride of sodium	129.85	6.70

Plate X., Figure 3,[2] represents the colors of the urine of this patient. The case continued to improve, and was discharged cured.

Case XVIII. Isaac Parker, private, Company D, 45th Mississippi Regiment. Light brown hair; fair complexion; blue eyes. Age, twenty-six. Height, six feet. Native of Mississippi. Has been in service three years. During this time, as well as during his entire life, has enjoyed good health. Weight in health, one hundred and sixty-five pounds. Admitted into

Case XVIII. Illustrating the changes of the temperature and urine in hospital gangrene.

[1] Omitted.

[2] Omitted.

the Second Georgia Hospital, Augusta, Ga., October 6, 1863, with a gunshot wound of left fore-arm, the ball entering near the wrist, and escaping near the elbow joint. The bones were fractured. At the time of admission, the parts were very highly inflamed, threatening mortification. Irrigation was employed, but without any effect in arresting the progress of the inflammation.

Hospital gangrene appeared in the wound on the 10th, the constitutional effects of which were so great as to require amputation, as affording the only chance for recovery.

October 14. — Amputation at middle third of arm, by Surgeon Doughty, in charge of Second Georgia Hospital (circular method). Chloroform administered, and its effects well borne. Patient being on quinine and iron, it was continued.

October 17. — Stump dressed; looks well, and general condition favorable. Treatment continued.

October 19. — Gangrene reappears in stump. Patient has fever. Quinine and iron continued, with generous diet. Saturated solution of sulphate of copper applied to the stump.

October 20. — Gangrene extending. Pulse frequent and feeble. Great restlessness and nervous irritability. Tongue dry. Constitutional symptoms well marked. (Tincture muriate of iron, gtts. x.; chlorate of potassa, grains v., three times a day. Saturated solution of sulphate of copper to wound.)

October 23. — General condition improved. Sloughs are being detached in large pieces. Treatment continued.

October 26. — General condition decidedly better. Granulations appearing in the stump. Treatment continued.

For the preceding facts in the history of this case, I was indebted to Assistant-Surgeon Christian, of the Second Georgia Hospital, who assisted me in the determination of the temperatures in this and in several other cases of hospital gangrene which I investigated at this hospital.

November 7. — Nine o'clock A. M. Pulse, 80. Respiration, 18. Temperature of hand, 32° C. (89.9° F.). Temperature of axilla, 37.3° C. (99.1° F.). Tongue clean and moist. Skin of trunk feels warm and dry. Stump improving. Continue treatment.

Five o'clock P. M. Pulse, 86. Temperature of hand, 31.2° C. (88.1° F.). Temperature of axilla, 37.4° C. (99.3° F.).

November 9. — Nine o'clock A. M. Pulse, 80. Respiration, 16. Temperature of hand, 31.3° C. (88.3° F.). Temperature of axilla, 38° C. (100.4° F.). Stump improving. Treatment continued.

Five o'clock P. M. Pulse, 80. Respiration, 16. Temperature of hand, 32.1° C. (89.8° F.). Temperature of axilla, 39.1° C. (102.3° F.).

November 10. — Nine o'clock A. M. Pulse, 80. Respiration, 16. Temperature of hand, 30° C. (86° F.). Temperature of axilla, 37.2° C.

(99° F.). Stump does not look so well; some swelling and redness, as if the gangrene was about to return.

Examination of Urine. — Amount of urine passed during twenty-four hours, November 8, 9 A. M., to November 9, 9 A. M., 720 CC. = grains 11,589.26. Specific gravity, 1,022. Light orange color. (See Plate XI., Figure 1.[1]) Heavy light-yellow deposit of urates, upon cooling (cold, frosty morning), and the sides of the glass vessel in which the urine was contained were encrusted with this light yellow deposit, and with large, well-formed, lozenge-shaped, highly colored (red) crystals of uric acid.

ANALYSIS OF URINE, NO. 12.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours.	11,589.26	
Urea	388.08	33.48
Uric acid	13.59	1.17
Free acid (three hours after collection)	28.82	2.48
Phosphoric acid	31.79	2.74
Equivalent of phosphorus in phosphoric acid	13.04	1.12
Sulphuric acid	19.75	1.74
Equivalent of sulphur in sulphuric acid	7.90	0.68
Chloride of sodium	77.61	6.69
Equivalent of chlorine in chloride of sodium	47.03	4.05

Eight o'clock P. M. Pulse, 86. Respiration, 16. Temperature of hand, 29.2° C. (84° F.). Temperature of axilla, 38.1° C. (100.6° F.).

Stump painful and swollen, and redder than normal, and appears as if the gangrene is about to return.

November 11. — Gangrene has returned, and all the constitutional symptoms are aggravated.

November 14. — Arm much swollen. Pulse, 102.

November 15. — Arm much swollen. Gangrene progressing; has a troublesome cough. The left lung appears to be chiefly affected. Patient nervous, restless. Spirits dejected. Countenance anxious and distressed. Dusky, leaden complexion.

Examination of Urine. — Amount of urine passed during twenty-four hours, November 14, 9 A. M., to November 15, 9 A. M., 800 CC. = grains 12,915. Specific gravity, 1,025. Slight light yellow deposit at the end of the twenty-four hours in which the urine was collected (weather warm and moist, a great change since the last observation upon the urine); slight deposit of uric acid upon the sides of the vessel. When the urine was treated with hydrochloric acid, there was an immediate and heavy precipitate of uric acid. So sudden and great was this precipitation, that at first I suspected that this was caused by albumen. Heat, however, did not throw down any precipitate, but dissolved even that produced by the hydrochloric acid.

[1] Omitted.

ANALYSIS OF URINE, NO. 13.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine excreted during twenty-four hours	12,915.00	
Urea	492.80	38.10
Uric acid	18.27	1.41
Free acid (six hours after collection)	32.03	2.40
Phosphoric acid	39.42	3.05
Equivalent of phosphorus in phosphoric acid	17.10	1.32
Sulphuric acid	26.89	2.08
Equivalent of sulphur in sulphuric acid	10.75	0.83
Chloride of sodium	86.24	7.06
Equivalent of chlorine in chloride of sodium	52.26	4.04

Six and one half o'clock P. M. Stump swollen and inflamed. No improvement of symptoms. Pulse 100, moderately full. Respiration, 20. Temperature of hand, 38.2° C. (100.7° F.). Temperature of axilla, 39.4° C. (102.9° F.). Skin moist. Tongue moist, with a very slight coating of light white fur.

November 16. — Continues in the same state. Arm much swollen. Troublesome cough. Lower lobes left lung dull upon percussion.

November 17. — Continues in much the same state. Lower lobes of left lung (same side with stump) dull upon percussion. A very slight improvement of general symptoms and stump. Gangrene still present. Appetite pretty good.

Examination of Urine. — Amount of urine passed during twenty-four hours from November 16, 9 A. M., to November 17, 9 A. M., 1,020 CC. = grains 16,360.80. Specific gravity, 1,020. Orange-red color. Reaction at end of fifty hours acid (clear, cool weather). Slight deposit in urine after standing. This under the microscope was found to consist of amorphous urates, and thousands of beautifully formed octohedral crystals of the oxalate of lime.

ANALYSIS OF URINE, NO. 14.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during twenty-four hours	16,360.80	
Urea	454.53	27.78
Uric acid	15.23	0.93
Free acid	25.91	1.52
Phosphoric acid	27.64	1.07
Equivalent of phosphorus in phosphoric acid	12.12	0.74
Sulphuric acid	25.88	1.52
Equivalent of sulphur in sulphuric acid	10.35	0.63
Chloride of sodium	138.23	8.44
Equivalent of chlorine in chloride of sodium	83.76	5.11

Plate XI.[1] represents the colors of the urine subjected to analysis, November 9, 15, and 17.

This case continued to improve very slowly, and lingered for many days before convalescence was fully established.

Commentary. — This, as well as the preceding case, No. XVII., illustrates in a striking manner the diurnal variations of the temperature in hospital gangrene, as well as the marked differences which sometimes exist between the temperatures of the central organs and of the extremities.

In the former one, No. XVII., the urine is observed to approach to the standard of health, and to lose its high color just as the local and general symptoms improve, whilst in the latter, No. XVIII., the urine becomes more highly colored, and recedes from the standard of health just in proportion to the increase of local and constitutional disturbance.

The analysis of the urine of the 9th of November is interesting, as showing the condition of this fluid just as the gangrene was reappearing.

The chemical examination of the urinary excretion is important not merely as affording materials for the determination of the nature of hospital gangrene, but also as affording valuable data for the institution of comparisons with other diseases, and especially with those, as small-pox and measles, which are due to the action of animal poisons. It is important also that the phenomena of hospital gangrene should be carefully compared with the phenomena of such a disease as typhoid fever, in which we have in like manner a large, irritated, inflamed surface, and most grave constitutional disturbances. If upon comparison the causes of local disturbance be equal in both diseases, then the excess of constitutional disturbances in the one or the other, as manifested by the variations and increase of certain constituents in the urine, might afford ground for reasoning as to the action of the causes producing the disease, as well as their nature and physical and chemical properties.

If we find an invariable increase of sulphuric acid in the urine of one disease, and an invariable decrease of this substance in the urine of another disease, we would naturally be led to examine the source of sulphuric acid in the urine, and to inquire if these differences do not point to differences in the chemical affinities and actions of the poisons producing the diseases. Thus if we knew the whole amount of sulphur existing in the animal body, and the

[1] Omitted.

proportions existing in the different tissues and in different articles of food, and, still further, the amount normally excreted in combination with oxygen in health and in different diseases, we may from such knowledge form a reasonable conclusion as to the tissues which have been especially affected by any poison inducing disease. These remarks apply to phosphoric acid, and to all the constituents of the urine. Such comparisons are especially interesting in two diseases — hospital gangrene and typhoid fever — which evidently appear to arise very much from the same causes, neglect of hygiene and crowding in filthy tents and hospitals.

Case XIX. Illustrating the changes of the temperature and urine in hospital gangrene.

CASE XIX. S. M. Perrin, private, Company C, 19th Regiment Arkansas Vols. Age, twenty. Dark hair dark gray eyes. Height, five feet nine inches. Weight in health, one hundred and sixty pounds. Wounded at battle of Chickamauga, September 19, 1863. Ball entered anteriorly two inches above ankle joint, and passed out on same side, making a flesh-wound of two and one half inches in extent. Patient's general health good at the time of the reception of this wound. Gangrene attacked the wound October 6th, ten days after his transference to Augusta, and seven days after his entrance into the Second Georgia Hospital. This patient had remained three days in the Presbyterian Church on Telfair Street immediately after his arrival in Augusta. Patient states that he had fever for two days before the appearance of gangrene in the wound. Under the action of quinine and iron and the local application of sulphate of copper, the wound improved and the gangrene appeared to have disappeared. On the 1st of November, however, the patient was seized with fever, and the gangrene returned.

November 6. — Nine o'clock A. M. Pulse 86, and full. Respiration natural. Bowels regular. Tongue clean and moist. Skin warm and dry. Temperature of hand, 31.1° C. (88° F.). Temperature of axilla, 37. 2° C. (98.9° F.). Wound about three and one half inches in diameter, and gangrenous in its upper portion. The treatment consists of tinct. mur. of iron, gtts. x., sulphate of quinia, grs. iii., three times a day Saturated solution of sulphate of copper to wound and nutritious diet.

Five o'clock P. M. Pulse, 98. Temperature of hand, 32.3° C (90.1° F.). Temperature of axilla, 38.4° C. (101.1° F.).

Eight o'clock P. M. Pulse 96, small and feeble. Temperature of hand, 38.2° C. (100.7° F.). Temperature of axilla, 39° C. (102.2° F.). Skin hot and dry. Tongue moist, pale, and coated with yellow fur at root.

November 7. — Nine o'clock A. M. Pulse, 84. Tongue clean and moist. Respiration, 18. Skin warm and dry. Temperature of hand, 33.2° C (91.7° F.). Temperature of axilla, 36.1° C. (97° F.). Much of the gangrenous matters have been removed with forceps and scissors. Granu-

lations are springing up beneath the slough. Treatment and diet continued.

November 8. — Nine o'clock A. M. Pulse, 86. Tongue clean and moist. Respiration, 18. Skin slightly moist and warm. Wound very much improved in appearance. Treatment and diet continued.

Five o'clock P. M. Pulse, 100. Respiration, 18. Temperature of hand, 34° C. (93.2° F.). Temperature of axilla, 39.2° C. (102.5° F.).

November 9. — Nine o'clock A. M. Pulse, 86. Respiration, 18. Temperature of hand, 30.2° C. (86.3° F.). Temperature of axilla, 38° C. (100.4° F.). Tongue clean and moist. Skin dry and warm. Sloughing has ceased, and the wound looks more healthy.

Eight o'clock P. M. Pulse, 90. Respiration, 18. Temperature of hand, 28° C. (82.4° F.). Temperature of axilla, 39.1° C. (102.4° F.).

November 10. — Nine o'clock A. M. Pulse, 80. Respiration, 18. Tongue clean and moist. Skin cool and slightly moist. Wound looking well and healing around the edges. Treatment and diet continued.

Examination of Urine. — Amount of urine collected during twenty-four hours, November 9, nine A. M., to November 10, nine A. M., 1,100 CC. = grains 17,715.20. Deep orange-colored, with heavy deposit of urates upon cooling (weather cool with frosty mornings). Hydrochloric acid produced an immediate and heavy deposit of light yellow crystals of uric acid. Specific gravity of urine, 1,024. Plate XII.[1] represents the color of this urine.

ANALYSIS OF URINE, NO. 15.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine excreted during twenty-four hours.	17,715.20	
Urea	677.60	38.19
Uric acid	16.43	0.92
Free acid (four hours after collection)	49.12	2.77
Phosphoric acid	48.78	2.75
Equivalent of phosphorus in phosphoric acid	21.41	1.208
Sulphuric acid	44.67	2.52
Sulphur in sulphuric acid	17.86	1.008
Chloride of sodium	149.07	8.307
Chlorine in chloride of sodium	98.38	5.49

Case XX. Illustrating the changes of temperature and urine during hospital gangrene.

Case XX. Sergeant J. J. Lamb, Company B, 5th Regiment Arkansas Vols. Age, twenty-one. Height, five feet ten inches. Weight in health, one hundred and sixty-five pounds. Reddish hair and gray eyes. Wounded at battle of Chickamauga, September 19th, in left leg, three inches below the knee, on the outer side. Only one opening appeared, and the ball could not be found. Was transferred a few days after the battle to Augusta, and was placed, together with two hundred and seventy-four

[1] Omitted.

other wounded men, in the Presbyterian Church. His wound appeared to be doing well and healing until the 8th of October, when the patient was taken with a chill followed by fever. On the 9th, the wound was painful and much inflamed, presenting a dark-blue ring around it. On the 10th, the dark-blue ring had assumed a black color. The patient suffered with another chill, followed by fever. The gangrene continued to extend, and on the 16th the skin and superficial fascia had become gangrenous for four inches in width and five in length. This dead tissue was removed, as far as possible, on this day.

October 17. — The back and upper portions of the wound are studded with healthy granulations, whilst in the lower parts gangrene is still progressing.

October 18. — A red spot, about the size of a silver half-dollar made its appearance on the right or inner side of the calf of the diseased leg, about four inches below the knee joint; at this part there was no wound or abrasion previous to the appearance of this discoloration. This spot rapidly changed its hue and extended its base, and on the 19th presented a black color, with an inflamed base, extending to the inflamed base of the original wound.

October 22. — The gangrenous wounds have formed a junction in front of the tibia.

October 25. — The gangrenous mass was removed, and consisted of skin and superficial fascia. The wound now encircled the leg with the exception of a strip of sound skin and tissue at the back of the calf of the leg, about one and a half inches in width. On this day a small red spot was visible about four inches above the external malleolus, which soon became gangrenous.

I was indebted to Assistant-Surgeon J. W. Warren, of the Third Georgia Hospital, for the preceding outline of this case. This officer also assisted me in the determination of the temperatures in this and in several other cases upon which I instituted inquiries at the second division of the Third Georgia Hospital.

October 30. — Eleven and one half o'clock A. M. Pulse, 94. Respiration, 20. Temperature of hand, 35.7° C. (96.3° F.). Temperature of axilla, 37.9° C. (100.3° F.). Tongue clean and moist; bowels regular; his bowels have been regular throughout. Treatment has consisted of tinct. mur. of iron, gtts. xx.; quinine, grs. iv.; whiskey, ℥ii., three times a day, and at bed-time, four grains of opium. Nutritious diet, eggs, chickens, and beef. The local treatment has been quite simple; the gangrenous wound was first burned with nitric acid, and followed by charcoal and yeast poultices. Complexion dusky; hectic flush about the cheeks. Wound below the knee exposes a raw surface of near forty square inches. Muscles in most parts denuded of all fibrous tissue, and of a slick red color, with some granulations. Gangrene is still extending, but to a limited extent, along a small portion of the border. Gangrene also exists in the diseased part near the ankle.

Examination of Urine. — Amount of urine collected during the past twenty-four hours, 810 CC. = grains 12,966.75. Specific gravity, 1,017. Deep orange-red color.[1] When first passed, clear, and of a strong acid reaction. At the end of fifty hours the reaction became alkaline, and a heavy deposit fell, consisting of the urates and phosphates (chiefly of the phosphates). In the sunlight, this light yellow deposit presented a brilliant, sparkling appearance, like spangles of silver. I have frequently noticed a similar appearance in the urine during convalescence from malarial fever. These shining silver bodies are large well-formed prismatic crystals of triple phosphate.

ANALYSIS OF URINE, NO. 16.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine excreted during twenty-four hours .	12,966.75	
Urea	374.22	28.87
Uric acid	10.58	0.81
Free acid (alkaline at end of fifty hours)	alkaline	–
Phosphoric acid	12.47	0.96
Equivalent of phosphorus in phosphoric acid . . .	5.45	0.42
Sulphuric acid	20.00	1.54
Equivalent of sulphur in sulphuric acid	8.00	0.61
Chloride of sodium	31.18	2.404
Equivalent of chlorine in chloride of sodium . . .	18.89	1.45

November 1. — Eleven o'clock A. M. Pulse, 88. Temperature of hand, 94° F. Temperature under tongue, 101° F. Temperature in axilla, 99° F.

Six o'clock P. M. Pulse, 112. Temperature of hand, 95° F. Temperature under tongue, 102° F. Temperature in axilla, 100° F. Gangrene still extending. Constitutional disturbances marked. In the morning this patient appears to be comparatively free from fever, and in the evening there is a marked rise in the temperature, and the pulse increases in frequency. Muscular and nervous forces greatly prostrated.

November 2. — The slough, from the gangrenous spot above the ankle, has this morning been removed, leaving a healthy granulating wound two inches in length, and about the same in diameter. No escharotic was applied to this gangrenous spot; nothing but the charcoal and yeast poultices. It is a matter of grave interest to determine whether or not the severe local applications, as nitric acid and sulphate of copper, may not be dispensed with. In many cases, the constitutional treatment appears to be the great means of arresting the disease. The practice of applying either nitric acid or the actual cautery, or any one of the more powerful caustics, to only circumscribed portions of the wound at any one time, as well as the frequent application of weak nitric acid, or of any severe styptic, as sulphate of copper, to the gran-

[1] See Plate No. XIII.

ulating surface, after the removal of the gangrene, is to be condemned. I have seen patients tortured day after day almost to death by the useless application of these severe remedies to healthy surfaces.

November 5. — Continues in much the same condition. Wounds appear to be improving somewhat.

Examination of Urine. — Amount of urine passed during twenty-four hours, November 4th, 12 M., to November 5th, 12 M., 1,120 CC. = grains 17,657.52. Specific gravity, 1,018. Urine red-colored. Deposit of large, well-formed, lozenge-shaped, highly colored (red) crystals of uric acid on side of vessel.

ANALYSIS OF URINE, NO. 17.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours.	17,957.52	
Urea	551.93	30.73
Uric acid	21.16	1.17
Free acid	35.73	1.908
Phosphoric acid	34.65	1.92
Equivalent of phosphorus in phosphoric acid	15.23	0.84
Sulphuric acid	23.96	1.33
Equivalent of sulphur in sulphuric acid	9.58	0.53
Chloride of sodium	98.31	5.41
Equivalent of chlorine in chloride of sodium	59.57	3.31
Chlorine by direct determination with nitrate of silver	52.83	2.94

The color of these two specimens of urine are represented in Plate No. 13.[1]

November 7. — Two red or inflamed spots were observed, one upon the external malleolus, and the other about two inches above the internal malleolus of the diseased leg. The latter disappeared (no local application being made to either of the spots); the former became gangrenous, and extended slowly. No puncture or abrasion could be observed upon either of these spots.

November 10. — Four o'clock P. M. Temperature of palm of hand, 73° F. Temperature under tongue, 99° F. Pulse, 100.

November 11. — Four o'clock P. M. Temperature of hand, 79° F.; under tongue, 101° F. Pulse, 104.

November 12. — Ten o'clock A. M. Temperature of hand, 73° F.; under tongue, 98° F. Pulse, 96.

Eleven o'clock A. M. Temperature of hand, 22.4° C. (72.4° F.). Temperature under tongue, 98° F. Pulse, 94. Respiration, 14.

Five o'clock P. M. Temperature of hand, 82° F. Temperature under tongue, 101° F. Pulse, 100.

November 13. — Eight o'clock A. M. Temperature of hand, 74° F.; under tongue, 99° F. Pulse, 98. Continues to improve slowly.

[1] Omitted.

The depression of the temperature in the extremities, as well as the feeble capillary circulation in this case, was interesting, not only as illustrating the true nature of the disease, and as indicating the principles of treatment, but also as throwing much light upon the formation of the gangrenous spots on the leg without any apparent abrasion.

Case XXI. Illustrating the changes of the temperature and urine in hospital gangrene.

Case XXI. B. J. Talley, Lieutenant, 20th Texas Regiment. Age, twenty-one. Gray eyes; light hair; fair complexion. Wounded at the battle of Chickamauga, 19th September, 1863, in the posterior fleshy portion of the right thigh, midway between the hip and knee joints. A few days after the battle was transferred to Augusta, and entered the Presbyterian Church, second division, Third Georgia Hospital. After remaining in the hospital several days, was sent to a private house, where he remained until the appearance of gangrene, and the patient returned to the Presbyterian Church.

Wound did well until the 18th of October, when gangrene set in. On this day the patient had a chill, followed by fever. The chill commenced at three o'clock P. M., and lasted about two hours. On the evening of October 18th, the wound at point of entrance presented an angry look, with an inflamed areola in the surrounding skin.

October 19. — Nitric acid applied to gangrenous wound, and five grains of quinine administered three times. Diet generous; soft-boiled eggs, beef, and chicken, etc.

October 20. — Bowels costive. Chill and fever again in the evening. Tongue red, coated, and moist. Very little appetite. Two compound cathartic pills prescribed in addition to treatment of yesterday.

October 21. — Patient again had fever, without the chill, however, in the evening. The pills did not act upon the bowels, and were repeated. Nitric acid applied daily to wound, and followed with charcoal poultices; quinine continued; half-grain of morphine administered at bed-time to procure rest.

October 22. — Bowels have been acted on. Appetite has not improved. Fever returned in the evening. Nitric acid applied, and wound dressed with charcoal and yeast poultice; five grains of quinine three times a day; and four grains of opium at bed-time.

October 24. — No change in symptoms; bowels costive; no improvement of appetite; chill preceded fever this evening. Two compound cathartic pills administered; local treatment continued; fifteen drops of tincture muriate of iron added to each dose of quinine; also, whiskey, f℥ii., three times a day.

October 25. — Bowels still costive; two compound cathartic pills given to be repeated in four hours. Patient has fever which was not preceded by chill. Treatment continued.

October 26. — Bowels have been acted on twice; the destruction of tissue goes on slowly.

No change of note in the treatment or progress of the disease until October 30, when there was some improvement in appetite; the tongue appeared less furred, and the febrile excitement appeared to be less.

The foregoing facts in the history of this case were furnished by Assistant-Surgeon Warren and Acting Assistant-Surgeon Henry F. Heriot, in charge of the second division Third Georgia Hospital.

October 31. — Wound dry, inflamed, and painful, having been dressed with dry, powdered charcoal; the patient suffers much pain. Constitutional symptoms well marked; high fever, flushed face, head much affected, at times severe pain, and an inclination to low muttering delirium. Gangrene still slowly progressing. Pulse about 94 in the morning, and over 100 in the evening. No nitric acid applied. Quinine is still continued. Tincture muriate of iron and whiskey are discontinued; also the anodyne.

Examination of Urine. — Amount of urine collected during twenty-four hours, 750 CC. = grains 12,012.4. Deep orange-red color.[1] Specific gravity, 1,018. No deposit after standing sixty hours. Reaction still strongly acid at the end of eighty hours.

ANALYSIS OF URINE, NO. 18.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours.	12,012.40	
Urea	404.25	33.65
Uric acid	9.32	0.77
Free acid (at end of eighty hours after collection)	28.87	2.403
Phosphoric acid	43.89	3.65
Equivalent of phosphorus in phosphoric acid	19.30	1.606
Sulphuric acid	25.00	2.08
Equivalent of sulphur in sulphuric acid	10.00	0.88
Chloride of sodium	19.32	1.68
Equivalent of chlorine in chloride of sodium	11.70	0.97

November 4. — Ten o'clock A. M. Pulse, 96. The death and removal of the tissues progress very slowly. Portions of the wound are improving. Dark pus of an unhealthy odor is now discharged. Bowels regular. Tongue nearly natural in appearance. Patient now takes no medicine. The local treatment of the wound consists of the application of concentrated solution of sulphate of copper, twice a day, followed by charcoal and yeast poultices.

November 5. — Pulse, 98 at ten o'clock A. M., and 108 at half-past four o'clock P. M.

Examination of Urine. — Amount of urine passed during the last twenty-four hours, November 4, twelve M., to November 5, twelve M. 1,275 CC. = grains 20,360. Specific gravity, 1,018. Deep orange-red color. No deposit; only slight turbidness thirty hours after collection.[2]

[1] Plate No. XIV. (Omitted.) [2] See Plate No. XIV. Fig. 2. (Omitted.)

ANALYSIS OF URINE, NO. 19.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	20,360.00	
Urea	785.40	38.52
Uric acid	22.00	1.08
Free acid (thirty hours)	40.25	1.97
Phosphoric acid	51.05	2.507
Equivalent of phosphorus in phosphoric acid . . .	20.61	1.01
Sulphuric acid	53.35	2.52
Equivalent of sulphur in sulphuric acid	21.34	1.04
Chloride of sodium	64.79	3.37
Equivalent of chlorine in chloride of sodium . . .	41.28	2.02

November 7. — Pus of an unhealthy character is still discharged, and the tissues are still sloughing. Pulse, at ten o'clock A. M., 96; at four P. M., 108. Temperature, at four o'clock P. M., in hand, 103° F.; under the tongue, 103.5° F. Tincture muriate of iron, gtts. xv., quinine, grs. iii., whiskey, f℥ii., three times a day; solution of sulphate of copper applied to wound, and followed with charcoal and yeast poultices.

November 9. — Ten o'clock A. M. Pulse, 96. Temperature of hand, 94° F.; under tongue, 101.75° F.

November 11. — Wound does not increase in size, but there is still some destruction of tissue.

Ten o'clock A. M. Pulse, 94. Temperature of hand, 90° F.; under tongue, 99° F. Chill and fever in the evening. Respiration, 18.

November 12. — Four o'clock P. M. Pulse, 108. Temperature of hand, 103° F. Temperature under tongue, 103.5° F. Hectic flush on cheek. Had a chill at three P. M. Tongue red at edges, and furred. Patient weak and nervous. Bowels costive.

November 13. — The discharge of pus from the wound is greater than usual, and more healthy. Appetite is very good; bowels continue regular; tongue slightly furred, red, and moist.

Ten o'clock A. M. Pulse, 90. Temperature of hand, 80° F.; under tongue, 100° F. Treatment continued.

November 14. — Considerable dead tissue came off with the poultice, showing healthy granulations in several small spots.

Ten o'clock A. M. Pulse, 100. Temperature of hand, 95° F.; under tongue, 100° F.

November 15. — Sloughing appears to have ceased. Some dead tissue has been removed, and healthy granulations were found to exist under the mass. The solution of sulphate of copper is very painful to the wound, and will therefore be discontinued. Charcoal and yeast poultices continued.

Ten o'clock A. M. Temperature of hand, 85° F.; under tongue, 101° F. Pulse, 100.

Four o'clock P. M. Temperature of hand, 100° F.; under tongue, 102° F.

November 16. — All dead tissue has been removed. The wound is now about four inches long and three inches wide, and presents a red granulating appearance. Treatment continued.

Nine o'clock A. M. Temperature of hand, 83° F.; under tongue, 99° F.

Five and a half o'clock P. M. Temperature of hand, 97° F.; under tongue, 100° F.

November 17. — Nine o'clock A. M. Pulse, 100. Temperature of hand, 90° F.; under tongue, 99.5° F. Wound looks well. Appetite good. Tongue still slightly furred. Bowels regular. Urine nearly normal in color. Treatment continued.

November 18. — Pulse, 96. Wound looks well. Simple cerate the only local application.

November 20. — Wound continues to improve; febrile symptoms almost entirely subsided, even in the latter part of the day. Pulse, 86.

November 21. — Pulse 80, at eight o'clock A. M.

November 22. — Wound heals very slowly, though it has a healthy granulating surface. Pulse, 88.

November 25.—All constitutional disturbances have disappeared. Appetite good; skin warm, moist, and soft. Tongue nearly natural; slightly red and coated. Wound healthy; fills up very slowly. The patient has been much reduced by the long suffering and the effects of the gangrene.

Case XXII. Illustrating the changes of the temperature and urine in hospital gangrene.

CASE XXII. R. D. Beck, private, Company I. 1st Regiment Florida Cavalry. Age, twenty-nine. Dark hair, gray eyes, dark complexion. Wounded at battle of Chickamauga, 20th September, 1863, in left foot; ball entered two inches below, and a little behind the external malleolus, passed downwards, and made its exit about three quarters of an inch to the left of the centre of the bottom of the heel. The bones were not injured, and the wound was considered slight. The patient remained in the field infirmary until the 28th of September, during which time the wound was treated with cold water. From thence was sent to Atlanta, and after remaining in hospital there for one night, was transferred to Augusta, where he was admitted into second division Third Georgia Hospital (Presbyterian Church) on the 1st of October.

From the 1st to the 26th of October, the wound was treated with cold-water dressing entirely, and the improvement was rapid; the orifice of exit was completely healed, and that of entrance nearly so. On the evening of the 26th, however, the patient complained of pain about the orifice of entrance.

No special change beyond a suppression of secretion and increased redness was noted by the attendant physician, Assistant-Surgeon Warren, on the 26th; but on the next day the skin for two inches around the orifice was highly inflamed, and accompanied by swelling. The

edges of the wound became elevated above the surrounding tissues, and everted. Nitric acid was applied freely, and the wound dressed with charcoal and yeast poultices, and half a grain of morphine administered at bed-time. These local changes in the wound were accompanied by fever. On the following day, 28th, the edges of the wound were still more elevated and everted, and a spot about the size of a silver ten-cent piece appeared to be gangrenous. The patient described the pain of the wound to be excruciating. In the evening, the patient complained of a chilly sensation, which was followed by fever. After applying nitric acid and charcoal poultices to the wound, the pain was so intense that the patient was unable to sleep. One and a half grains of morphine, and one hundred and fifty drops of laudanum, failed to produce sleep at night, or to diminish the pain. Tincture of opium (laudanum) was then poured upon the wound, which gave temporary relief. This application was repeated in the morning, and in like manner afforded temporary cessation of the severe pain; but this local treatment soon failed entirely to relieve the excruciating pain.

October 30. — Patient nervous and restless. Suffers intense pain in the gangrenous wound. Opiates have little or no effect upon this. Pulse rapid and feeble. Skin hot and dry. No appetite. Countenance distressed and anxious. Complexion dusky. Gangrene progressing.

Examination of Urine. — Amount of urine collected during twenty-four hours, 550 CC. = grains 8,817.56. Specific gravity, 1,017. Urine deep red. Reaction at end of eighty hours strongly acid. Light yellow deposit, with a pellicle on the top.

ANALYSIS OF URINE, NO. 20.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during twenty-four hours	8,817.56	
Free acid	11.16	1.26
Urea	279.51	31.47
Uric acid	6.07	0.68
Phosphoric acid	12.87	1.44
Equivalent of phosphorus in phosphoric acid	5.65	0.64
Sulphuric acid	18.41	2.08
Equivalent of sulphur in sulphuric acid	7.36	0.83
Chloride of sodium	12.70	1.45
Equivalent of chlorine in chloride of sodium	8.30	0.94

Plate No. XV.[1] represents the color of this specimen of the urine.

Gangrene continued to spread in the wound until the 7th of November, when it was arrested.

During the existence of the gangrene the patient had no appetite, and took very little nourishment. He suffered most of the time with very severe pain, and had fever every evening, which in the first four

[1] Omitted.

evenings was preceded by chilly sensations, but there was at no time a regularly formed chill. The bowels were uniformly costive, and it was necessary to keep them open by castor-oil or compound cathartic pills (U. S. P.), administered almost every day. Morphine was administered in accordance with the pain, and five grains of quinine three times a day were administered on the 29th and 30th of October.

November 5. — Wound gangrenous and painful. Patient restless. Constitutional symptoms well marked. No appetite. Pulse rapid and feeble. Marked diurnal variations of temperature. Well-marked febrile symptoms in the evening.

Examination of Urine. — Amount of urine excreted during twenty-four hours, November 4, 12 M., to November 5, 12 M., 1,120 CC. = grains 17,776. Specific gravity, 1,010. Deep red color, as in Plate No. XV., Figure 1.[1] Slight turbidness at the end of thirty hours.

ANALYSIS OF URINE, NO. 21.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during twenty-four hours	17,776.00	
Urea	327.71	18.21
Uric acid	9.15	0.51
Free acid	24.14	1.35
Phosphoric acid	29.10	1.63
Equivalent of phosphorus in phosphoric acid	12.79	0.71
Sulphuric acid	22.66	1.27
Equivalent of sulphur in sulphuric acid	9.06	0.65
Chloride of sodium	36.22	2.03
Equivalent of chlorine in chloride of sodium	21.94	1.23

November 7. — Gangrene appears to be arrested. Nearly all the dead tissues have sloughed out, or been removed with the knife, scissors, and forceps, leaving a healthy granulating wound, three inches in length, and two in breadth, and of considerable depth. The gangrene appeared to spread until all the inflamed border of skin which had in the earlier periods of the disease presented a deep livid red and purple color, was destroyed. The improvement of the local symptoms was attended with corresponding improvement in the constitutional symptoms. The pain and fever subsided, and the bowels became regular; the nervousness and anxiety disappeared, and the pulse, which had never been less than one hundred and eight beats to the minute in the morning, fell to ninety on the 7th, and the appetite improved.

This case continued to improve, and was sent home on furlough, November 22d.

Case XXIII. Illustrating the changes

CASE XXIII. J. C. Carter, private, Company F, 6th Florida Regiment. Age, twenty-two. Gray eyes. Light hair, inclining to red. Fair complexion. Wounded on the 19th of Septem-

[1] Omitted.

of the temperature and urine in hospital gangrene.

ber, 1863, at Chickamauga, in right arm; musket-ball entered the radial side of fore-arm, about two inches below the external condyle of the humerus, and made its exit about one inch above the internal condyle of the humerus. Remained in the field infirmary until the 23d, and from thence sent to Atlanta, where he suffered with a hemorrhage from the arm on the 25th, six days after the reception of the wound. On the 28th, transferred to Augusta, and entered the Presbyterian Church on the 1st of October. On the 3d or 4th of this month, the patient had several hemorrhages; the blood, which was arterial in its character and color, issued from the orifice of exit. The hemorrhage was restrained by the application of lint, saturated with persulphate of iron, to the bleeding vessel. The wound was packed with lint, saturated with this styptic, and a compress was applied. From this time to the 17th of October, the wound appeared to progress favorably, when in the evening of this day it was observed that the skin around the orifice of exit began to look red and inflamed. This change was accompanied by a sensation of considerable pain in the wound, and the skin became hot and dry, with a peculiar flush upon the cheeks. Pulse accelerated. Patient nervous and restless. Bowels costive. Two compound cathartic pills were prescribed, and acted gently upon the bowels.

October 18. — A dark ring, one eighth of an inch in diameter, encircles the orifice of the wound, which is now gangrenous. The skin adjacent to the deeper purple areola is of a scarlet-red hue. There is some swelling, but the edges of the wound are upon a level with the surrounding tissues. Skin warm and moist. Tongue pale, moist, and coated. Bowels regular. Febrile excitement increases as the day advances, and towards evening the cheeks become much flushed. (Whiskey, f℥iss.; tinct. mur. of iron, gtts. xv.; quinine, grains v., three times a day. Nutritious diet. Nitric acid applied to the wound, and followed by charcoal and yeast poultices. Opium or morphine at night.)

October 28. — The disease progressed steadily up to this date, the gangrene slowly destroying the tissues adjacent to the wound. At this time the wound is three inches in length and two inches in width. The skin around the wound has assumed a natural color, and the gangrene appears to be making but little progress. Up to the present time the treatment above mentioned has been pursued; from an insufficiency of supply, however, both the constitutional and local remedies were stopped. On the 30th, tincture of iodine was substituted for the nitric acid.

November 3. — Much of the dead tissue has been removed. There are as yet no granulations, and the denuded tissues are of a much paler hue than in healthy wounds. Patient had quite a severe hemorrhage this morning. The blood coagulated, forming a firm clot.

Several hemorrhages again, November 4th and 5th. Persulphate of

iron applied to bleeding surface, and tourniquet applied on brachial artery. Gangrene has again appeared in several spots in the wound.

The questions of amputation and of ligation were discussed, but it was decided by his attendant surgeons to attempt to save the arm. Patient very weak and pale from the loss of blood. Hectic flush upon cheek.

November 7. — The solution of the persulphate of iron has caused an extensive slough. After the removal of this, live tissue can be seen; in three fourths of the surface of the wound the color is pale; in the other fourth of the wound we have the dark gray and greenish slough, and gangrene is still progressing in these parts. The attendant medical officer, Assistant-Surgeon Warren, furnished the preceding facts in the history of this case.

November 10. — Patient improving. Granulations are springing up in the wound, although they look pale and small. The hectic flush upon the cheek is not so bright as during the progress of the gangrene.

Four and one half o'clock P. M. Pulse, 120. Temperature of hand, 99° F.; under tongue, 101.5° F. Appetite pretty good. Tongue moist and pale. Complexion pale and anæmic. The effects of the hemorrhages are plainly visible in the pale lips and tongue, and the transparent look of the fingers.

Examination of Urine. — Amount of urine passed during twenty-four hours, 1,475 CC. = grains 23,439.07. Specific gravity, 1,009. Orange-colored, with a tinge of red, as represented in Plate No. XVI.[1]

ANALYSIS OF URINE, NO. 22.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours.	23,439.07	
Urea	364.98	15.57
Uric acid	11.61	0.49
Free acid (three hours after passage; clear, cold day)	20.44	0.87
Phosphoric acid	19.98	0.85
Equivalent of phosphorus in phosphoric acid	8.78	0.37
Sulphuric acid	15.17	0.64
Equivalent of sulphur in sulphuric acid	6.06	2.58
Chloride of sodium	81.04	3.45
Equivalent of chlorine in chloride of sodium	49.11	2.09

November 11. — Nine o'clock A. M. Temperature of hand, 92.5° F.; under tongue, 100° F. Pulse, 108. Tongue moist, pale, and coated. Skin moist and soft. Bowels regular.

November 12. — Ten o'clock A. M. Temperature of hand, 98° F.; under tongue, 100.25° F. Pulse, 100.

November 14. — Nine and one half o'clock A. M. Pulse, 100. Temperature of hand, 97° F.; under tongue, 100° F. Gangrene is now en-

[1] Omitted.

tirely removed; all the sloughs from the wound have separated, and granulations cover the surface from whence the slough has been removed. The color of the granulations is much deeper and brighter.

November 15. — The size of the wound is becoming smaller, and it is fast filling up with healthy granulations. The sulphate of copper is no longer applied, and simple cerate is the only local application used. The patient is still taking whiskey and tincture muriate of iron. Appetite good. Skin warm and soft. Tongue natural. Bowels regular. Spirits cheerful.

Eleven o'clock A. M. Temperature of hand, 91° F.; under tongue, 100° F.

November 17. — Patient still weak from loss of blood, but is rapidly improving.

November 20. — Wound entirely filled up with healthy granulations, and patient walking about. Continued to improve until the 17th, when he suffered from a slight attack of rheumatism. Shortly after this, was sent home on furlough.

Commentary. — It is a point of some interest that after the severe hemorrhage which placed the life of the patient in danger, the gangrene rapidly disappeared, and the wound improved. The only difference in the treatment induced by the hemorrhage was the local application of the persulphate of iron. How far this styptic tended to induce healthy action in the diseased parts, we are unable to determine; it did without doubt exert some beneficial effects; we are, however, from many similar facts, inclined to attribute the rapid improvement of the wound, in great measure at least, to the hemorrhage.

Case XXIV. Illustrating the changes of the urine and temperature in hospital gangrene.

Case XXIV. Francis Quinn, private, Company C, 13th Regiment Louisiana Vols. Age, thirty-nine. Dark hair; dark complexion; gray eyes. Wounded on the 20th of September, at battle of Chickamauga. Minie-ball entered two and a half inches above, and to the left of the left nipple, and passing through the lower border of the pectoralis major muscle, and onwards through the lower part of the axillary space, made its exit along the lower border of the scapula, about one and a half inches from the angle.

The wound did well after entrance of patient into second division (Presbyterian Church) Third Georgia Hospital, Augusta, until about the 12th of October, when the patient complained of being chilly; this sensation lasted about one hour, and was followed by fever, which lasted about six hours. On the following day the wound was found to be gangrenous. Five grains of quinine, three times a day, were administered, and one half-grain of morphine at bed-time.

October 14. — Patient again had chill and fever. (Quinine continued.

Nitric acid applied to gangrenous and adjacent tissues, and followed with charcoal and yeast poultice.)

October 15. — Gangrene progressing. Febrile symptoms well marked in the evening. Tongue pale, moist, and slightly coated. Skin in the morning feels cool and moist. No appetite. Nervous and restless. The constitutional and local treatment was continued, with the addition of creosote wash.

October 25. — The gangrene has continued to progress, with fever every evening, the febrile excitement being greatest upon alternate evenings. Gangrene is making its ravages along and adjacent to the track of the ball. Bowels costive. Appetite poor. Tongue pale, moist, and slightly coated. (Continue quinine; tincture muriate of iron, gtts. xv.; whiskey, f℥ii., three times a day. The supply of nitric acid being limited, tincture of iodine was substituted as a local application, and the charcoal and yeast poultices continued. Four grains of opium substituted for the morphine at bed-time.)

October 26. — Condition unchanged. Bowels costive. Two compound cathartic pills administered, which produced the desired effect.

October 29. — Patient again suffered with chill, followed by fever. The supply of quinine was exhausted, and no other agent was substituted by his attendant physician.

October 30. — Gangrene appears to be at "stand-still," and if it is extending at all, it is too slow to be observed. Appetite improving very slowly. Bowels moved once. Supply of tincture muriate of iron and whiskey exhausted. Nothing substituted.

October 31. — Continues in much the same condition. Bowels costive. Constitutional symptoms well marked.

Examination of Urine. — Amount of urine passed during the past twenty-four hours, 1,020 CC. = grains 16,284.84. Specific gravity, 1,014. Deep orange-red color, as shown in Plate No. XVII.[1] Deposit of well-formed, lozenge-shaped crystals of uric acid, of a bright red color, shortly after passage of urine. Still quite acid at the end of eighty hours.

ANALYSIS OF URINE, NO. 23.

Elements	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	16,284.84	
Urea	361.28	22.18
Uric acid	16.86	1.03
Free acid (eighty hours after collection)	26.70	1.64
Phosphoric acid	28.27	1.73
Equivalent of phosphorus in phosphoric acid	12.42	0.76
Sulphuric acid	18.82	1.15
Equivalent of sulphur in sulphuric acid	7.52	0.46
Chloride of sodium	62.83	3.85
Equivalent of chlorine in chloride of sodium	38.07	2.33

[1] Omitted.

November 1. — Wound still gangrenous in places, but the spread of the gangrene is slow.

Nine o'clock A. M. Pulse, 100. Temperature of hand, 87.5° F.; under tongue, 100° F.

Five o'clock P. M. Pulse, 104. Temperature of hand, 88.5° F.; under tongue, 101° F.

November 4. — Patient improving slowly. It is no longer necessary to administer opium at night. Bowels still costive.

Ten o'clock A. M. Pulse, 94. Temperature of hand, 89° F.; under tongue, 100° F.

November 5. — Gangrene is arrested. Wound granulating in spots. Tongue more natural. Bowels regular. The patient is still, however, nervous and weak, with a swollen, unhealthy complexion. His eye is more cheerful, and the expression of his countenance is brighter.

Examination of Urine. — Amount of urine passed during twenty-four hours, November 4, 12 M., to November 5, 12 M., 1,470 CC. = grains 23,450.95. Specific gravity of urine, 1.018. Orange-red color, as in Plate No. XVII.[1] Lateritious deposit of highly colored, lozenge-shaped crystals of uric acid, at the end of thirty hours.

ANALYSIS OF URINE, NO. 24.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	23,450.95	
Urea	486.71	20.75
Uric acid	16.89	0.72
Free acid (thirty hours after collection)	47.53	2.02
Phosphoric acid	31.69	1.35
Equivalent of phosphorus in phosphoric acid	13.93	0.59
Sulphuric acid	21.68	0.902
Equivalent of sulphur in sulphuric acid	8.67	0.36
Chloride of sodium	203.74	6.68
Equivalent of chlorine in chloride of sodium	123.46	5.26

November 6. — Wound looks healthy. Granulations can be seen all over the wound. Appetite greatly improved.

November 7. — Continues to improve. A cloth greased with mutton suet is the only application used now.

November 9. — Wound continues to fill up with healthy granulations.

Nine o'clock A. M. Temperature of hand, 91° F.; under tongue, 101° F. Pulse, 94.

Four and one half o'clock P. M. Temperature of hand, 93° F. Temperature under tongue, 101.5° F. Pulse, 100.

November 10. — Wound is contracted, until it is not more than half its former size. Patient is walking about.

[1] Omitted.

Nine and one half o'clock A. M. Temperature of hand, 90° F.; under tongue, 99° F. Pulse, 94.

November 12. — Three and one half o'clock P. M. Temperature of hand, 99° F.; under tongue, 101° F. Pulse, 100.

November 18. — Wound very small, and in ten days it will probably be healed up.

November 25. — Continued to improve steadily, and the wound was almost entirely healed, when the patient was seized with hemorrhage from the lungs. It was not determined whether this was the result of the blow upon the left chest by the ball. The hemorrhage was slight.

Case XXV. Illustrating the changes of the temperature and urine in hospital gangrene.

CASE XXV. F. M. Sanchez, Confederate soldier. Wounded at Chickamauga. Flesh-wound of shoulder. Transferred to Augusta, and entered the Presbyterian Church. Was not attacked for two weeks after gangrene prevailed extensively. The gangrene attacked the point or wound of entrance of the ball. The constitutional symptoms were well marked.

October 30. — Gangrene has been prevailing about twelve days. Febrile symptoms well marked in the evening. Complexion sallow. Bowels constipated. Appetite poor. Takes some food, however. Diet generous. Six soft boiled eggs, and chicken and beef.

Examination of Urine. — Amount of urine collected during twenty-four hours, 800 CC. = grains 12,826.80. Urine orange-red, as represented in Plate No. XVIII.[1] After standing thirty hours, moderately heavy orange-yellow deposit. Specific gravity of urine, 1,018. Reaction strongly acid at the end of sixty hours, although the weather is quite warm.

ANALYSIS OF URINE, NO. 25.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during twenty four hours .	12,826.80	
Urea	468.16	36.50
Uric acid	10.45	0.81
Free acid	33.88	2.64
Phosphoric acid	33.51	2.61
Equivalent of phosphorus in phosphoric acid . . .	14.62	1.13
Sulphuric acid	23.87	1.86
Equivalent of sulphur in sulphuric acid	9.54	0.74
Chloride of sodium	49.28	3.84
Equivalent of chlorine in chloride of sodium . . .	29.96	2.33

CASE XXVI. A. J. Petty, private, 34th Mississippi Regiment, Company C. Age, twenty-five. Light brown hair; blue eyes. Wounded at Chickamauga, September 19, 1863. Transferred to Augusta, second

[1] Omitted.

division, Third Georgia Hospital. Minie-ball struck the right foot in the region of the ankle, and fractured the external malleolus. Gangrene appeared in the wound about ten days after entering the crowded Presbyterian Church. The sufferings of this patient have been intense; the gangrene burrowed deeply amongst the tendons and bones of the instep, exposing a wound on the side of the foot and over the instep, between five and six inches in diameter. The constitutional symptoms have been well marked; rapid, feeble pulse; dusky, leaden hue; depressed spirits; constipated bowels; and febrile excitement daily, and especially towards the close of the day.

November 10. — The wound presents a ragged mass of fibrous tissue, muscles, tendons, and bones, with everted edges, surrounded by a high-colored areola in the skin. Complexion pale, anæmic, with hectic flush upon the cheeks. Pulse 112, small and feeble. During the past two weeks his pulse has varied from 110 to 115 in the morning, and from 120 to 130 in the evening. Nervous and restless. Temperature of axilla in the morning, 39° C. (102.2° F.). Gangrene still extending amongst the tendons and bones of the foot. Wound emits a most horrible stench. Some pus is now secreted. The treatment has consisted of tincture muriate of iron, gtts. xv., quinine, grains iii., and whiskey, f℥i. p., three times a day, with nitric acid as a local application.

Examination of Urine. — Amount of urine collected during twenty-four hours, 920 CC. = grains 14,833.50. Specific gravity, 1,023. Orange-red color, as in Plate XVIII.[1] No deposit.

ANALYSIS OF URINE, NO. 26.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during twenty-four hours	14,833.50	
Urea	439.20	29.60
Uric acid	22.62	1.52
Free acid (one or two hours after passage)	17.71	1.19
Phosphoric acid	26.11	1.76
Equivalent of phosphorus in phosphoric acid	11.47	0.77
Sulphuric acid	9.46	0.63
Equivalent of sulphur in sulphuric acid	3.78	0.25
Chloride of sodium	198.35	13.30
Equivalent of chlorine in chloride of sodium	120.20	8.104

Case XXVII. Illustrating the changes of the temperature and urine in hospital gangrene.

CASE XXVII. R. L. Jackson, private, 25th Georgia Regiment, Company C. Gunshot wound of left fore-arm, received in battle of Chickamauga, September 19, 1863. Ball entered at inner side of lower end of radius, and passing through wrist joint, emerged at carpo-metacarpal articulation. After his entrance into the Second Georgia Hospital, Augusta, Ga., the

[1] Omitted.

wound inflamed greatly, and October 12 it became gangrenous. The disorganization was so rapid, the marks of inflammation and infiltration extending to the elbow joint, it was deemed expedient to remove it. Amputation was performed by the attendant surgeon on the 16th of October, in the lower third of the arm, by the circular method. Chloroform was administered with good effect.

October 19. — The stump was dressed, and it was found that the gangrene had returned.

October 20. — Gangrene increasing. Pulse 90, quick and feeble. (Tincture muriate of iron, gtts. x., chlorate of potassa, grains v., three times a day. Saturated solution of sulphate of copper applied to the wound. Diet, soup, beef tea, eggs, and milk punch.)

October 23. — Slight improvement in stump. General health improving. Pulse 84, and full. Tongue clean and moist. Treatment and diet continued.

October 24. — Gangrene disappearing. General condition the same. Treatment and diet same.

October 27. — Gangrene has disappeared. General health very much improved. Local treatment discontinued. Constitutional treatment and diet continued.

November 6. — Nine o'clock A. M. Stump granulating. Pulse 92, and full. Tongue clean and moist. Temperature of hand, 37.3° C. (99.1° F.). Temperature of axilla, 39.1° C. (102.4° F.). Treatment and diet continued.

Five o'clock P. M. Temperature of hand, 37.4° C. (99.4° F.). Temperature of axilla, 38.3° C. (101° F.).

November 7. — Pulse 84, and full. Tongue clean and moist. Temperature of hand, 34.1° C. (93.4° F.); in axilla, 38° C. (101.5° F.). Treatment and diet continued.

November 8. — Stump looking well, and healing rapidly. Pulse 80, and full. Tongue clean and moist. Temperature in hand, 34.2° C. (93.6° F.); in axilla, 36.3° C. (97.4° F.). Treatment and diet continued.

Five o'clock P. M. Temperature in hand, 35° F.; in axilla, 36.4° F.

November 9. — Pulse 80, and full. Tongue clean and moist. Continues to improve. Stump looks healthy; healthy florid granulations; laudable pus. Appetite and spirits good. Complexion clear. Temperature of hand, 34.2° C. (93.6° F.); in axilla, 36.3° C. (97.34° F.).

Examination of Urine. — Amount of urine collected during twenty-four hours, November 8th, 9 A. M., to November 9th, 9 A. M., 1050 CC. = grains 16,777.95. Specific gravity, 1,015. Urine orange-colored, as in Plate XIX.[1]

Deposit upon the sides of the glass vessel of well-defined, lozenge-shaped, red crystals of uric acid.

The precipitation of the crystallized uric acid occurred shortly after

[1] Omitted.

the urine was voided, as they were observed upon the sides of the glass vessel before the collection of the urine during twenty-four hours had been completed.

Eight o'clock P. M. Temperature in hand, 32° C. (89.6° F.); in axilla, 38.1° C. (100.6° F.).

ANALYSIS OF URINE, NO. 27.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	16,777.95	
Urea	355.74	21.20
Uric Acid	16.53	0.98
Free Acid	28.29	1.68
Phosphoric Acid	23.93	1.42
Equivalent of phosphorus in phosphoric acid . . .	10.51	0.62
Sulphuric acid	19.30	1.15
Equivalent of sulphur in sulphuric acid	7.72	0.46
Chloride of sodium	129.36	7.70
Equivalent of chlorine in chloride of sodium . . .	78.39	4.67

Case XXVIII. Illustrating the changes of the temperature and urine in hospital gangrene.

Case XXVIII. Bennet Bushing, private, 25th Texas Regiment, Company K, native of Poland. Age, thirty-nine. Height, five feet six inches. Weight, one hundred and sixty-three pounds in health. Gray eyes; black hair. Has resided in America eleven years, in Walker County, Texas. Has been in service of the Confederate States two years. Has enjoyed good health during this time. Wounded at battle of Chickamauga, September 19, 1863, by a fragment of a bomb-shell, which struck the anterior surface of the leg about two inches above the ankle joint. The general health was good at the time of the reception of the wound, and continued so after his transference to Augusta and entrance into the Second Georgia Hospital, until the 6th of October, when the wound commenced to inflame, and became red and indurated around the edges.

October 7. — The wound was filled with the characteristic gray and greenish matter of hospital gangrene. At this time the patient had fever, but whether it preceded or followed the appearance of the gangrene, I was unable to ascertain, as no notes were taken of this case until the 2d of November.

November 2. — Wound improving; healthy granulations springing up in most parts, and only slight gangrene in several small circumscribed spots. Complexion sallow. Pulse weaker and more accelerated than usual in health, but fuller and stronger than in cases where hospital gangrene is progressing.

November 3. — Continues to improve.

Examination of Urine. — Amount of urine passed from November 2, 1 o'clock P. M., to November 3, 1 o'clock P. M. (twenty-four hours), 1,560 CC. = grains 24,895.20. Color of urine deep yellow, with a slight

tinge of red, as in Plate No. XX.,[1] Figure 1. Specific gravity, 1,012. Reaction after thirty hours, very slightly acid. The degree of acidity of the urine appears to depend, in many cases, upon the phosphoric acid, and the reason why febrile urine resists decomposition longer than the urine of health and convalescence, may be connected in great measure with the superabundance of phosphoric acid.

No deposit at end of thirty hours, only slight turbidness.

ANALYSIS OF URINE, NO. 28.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine excreted during twenty-four hours	24895.20	
Urea	432.43	17.37
Uric acid	7.38	0.29
Free acid (thirty hours)	18.01	0.72
Phosphoric acid	30.75	1.23
Equivalent of phosphorus in phosphoric acid	13.52	0.54
Sulphuric acid	17.12	0.68
Equivalent of sulphur in sulphuric acid	6.84	0.272
Chloride of sodium	180.18	7.23
Equivalent of chlorine in chloride of sodium	109.49	4.32

November 6. — Nine and a half o'clock A. M. Pulse 94, full. Respiration, 16. Tongue very slightly coated and moist. Temperature of hand, 35.2° C. (95.3° F.). Temperature of axilla, 39.1° C. (102.3° F.). Wound granulating, except at its inferior border. (Mur. tincture of iron, gtts. x., chlorate of potassa, grs. v., three times a day. Sat. solution of copper to wound. Diet nutritious.)

Eight o'clock P. M. Pulse 100, full and strong. Respiration, 16. Tongue clean and moist. Temperature of hand, 37° C. (98.6° F.); of axilla, 38.4° C. (101.1° F.).

November 9. — Nine o'clock A. M. Pulse 84, full. Respiration, 16. Tongue clean and moist. Temperature of hand (cold frosty morning), 33.4° C. (92.1° F.); of axilla, 36.1° C. (96.9° F.). Wound continues to improve. Constitutional treatment continued. Solution of sulphate of copper discontinued. Wound dressed with dry lint.

Five o'clock P. M. Temperature of hand, 34.3° C. (93.7° F.); of axilla, 38.2° C. (100.7° F.).

November 10. — Nine o'clock A. M. Pulse 80, full. Respiration, 16. Tongue clean and moist. Temperature of hand, 34° C. (93.2° F.); of axilla, 37.2° C. (98.9° F.). Wound looking well. Treatment of yesterday continued. This case continued to improve, and was discharged cured.

Commentary. — This case illustrates the character of the urine just at a favorable turn in the disease. Although the wound retains its former dimensions, yet when healthy granulations form, and laudable pus is secreted, the urinary excretion rapidly returns

[1] Omitted.

to the normal standard, both in color and composition. The more active and extensive the gangrene, the farther does the urinary excretion depart from the standard of health. The variations are especially evident in the changes in the amounts of the phosphoric acid, uric acid, urea, and coloring matters. It is important to bear in mind, that when comparisons are instituted to determine the extent of the urinary excretions, we should regard the worst cases of hospital gangrene as almost in a state of actual starvation, for they are generally without any appetite for food. The comparison should be instituted, therefore, with the standard of the urine in starvation during health.

Even in very slight cases of hospital gangrene, if the disease be progressing, the constitutional symptoms are well marked; as manifested by the changes of the urine, of the circulation, of the complexion, and of the general nutrition of the body.

Case XXIX. Illustrating the changes of the temperature and urine in hospital gangrene.

Case XXIX. P. C. Kenton, Company C, 1st Louisiana Regiment. Private. Age, thirty-seven. Dark gray eyes; brown hair. Five feet eight inches in height. Wounded at Chickamauga, September 20, 1863. Ball entered one inch above, and on a line with internal malleolus of left leg, and ranging upwards and backwards, passed out two and a half inches above its entrance. Was transferred to Augusta, Ga., and entered the Second Georgia Hospital. General health good after admission, and wound doing well. Wound was considered slight, and was rapidly healing, when, on the 7th of October, the wound was painful and red, with an indurated border several inches around the edges, and the patient complained of severe pain in the leg, and manifested high febrile symptoms.

October 9. — Gangrene well marked and progressing. The usual constitutional and local treatment employed in this hospital was used in this case, and the wound gradually assumed a healthy appearance with florid granulations.

November 2. — General symptoms good. Appetite excellent. Gangrene has entirely disappeared from the wound, which is now two and a half inches in breadth and four inches in length. Bowels regular.

November 3. — Continues to improve.

Examination of Urine. — Amount of urine passed during eight hours from November 3, 4 o'clock A. M., to 12 o'clock P. M., 470 CC. = grains 7,466.60. Specific gravity, 1,009. Deep yellow, inclining to light orange color, as represented in Plate No. XX.,[1] Figure 2. Reaction after thirty hours, acid, clear. No deposit.

November 6. — Nine o'clock A. M. Pulse 86, full. Respiration, 16. Bowels regular. Tongue clean and moist. Wound continues to improve. Temperature of hand, 31.2° C. (88.1° F.); of axilla, 36.2° C. (97.1° F.).

[1] Omitted.

Five o'clock P. M. Temperature of hand, 31.1° C. (86.2° F.); of axilla, 37.3° C. (99.1° F.). Pulse 88, full.

ANALYSIS OF URINE, NO. 29.

Elements.	Urine collected during 8 hours, contained grains	1,000 parts of urine contained.
Amount of urine collected during eight hours, Nov. 3	7,466.60	
Urea	101.33	13.45
Uric acid	1.48	0.19
Free acid	7.23	0.96
Phosphoric acid	4.92	0.64
Equivalent of phosphorus in phosphoric acid	2.16	2.89
Sulphuric acid	3.22	0.43
Equivalent of sulphur in sulphuric acid	1.28	0.17
Chloride of sodium	43.42	5.81
Equivalent of chlorine in chloride of sodium	26.31	3.57

November 9. — Nine o'clock A. M. Pulse 82, and full. Tongue clean and moist. Wound rapidly filling up with healthy granulations. Temperature of hand, 29° C. (84° F.). Temperature of axilla, 37.1° C. (98.8° F.).

Eight o'clock P. M. Pulse, 86. Temperature of hand, 30.3° C. (86.5° F.); in axilla, 38.1° C. (100.58° F.).

Case XXX. Illustrating the changes of the temperature and urine in hospital gangrene.

CASE XXX. I. W. Smith, private, 41st Tennessee Regiment, Company D. Age, twenty-one. Height, five feet six inches. Weight, one hundred and thirty-five pounds. Native of Tennessee. Has resided a considerable portion of his life in Alabama. Brown hair; light grayish eyes. Has never had typhoid fever. Had chills and fever, and pneumonia during the month of December, 1862. Wounded 16th of September, 1863, at battle of Chickamauga. Ball passed through the fleshy part of the arm near the elbow. Was transferred to Augusta, and remained two days at the depot before entering the Second Georgia Hospital. Gangrene appeared in the wound about the 10th of October, some fifteen days after his entrance into this hospital. Had fever about the time that the gangrene was making its appearance, with pain in the bones and loss of appetite, but suffered no special pain in the wound. After progressing two weeks, the gangrene was arrested on the 24th of October. The gangrene caused extensive sloughing upon the inner part of arm and elbow.

November 3. — Patient appears to be in good health, with the exception of the wound, which is about three inches in diameter. Wound covered with red, healthy granulations, which discharge thick, laudable pus. Patient walks about. Spirits good. Appetite excellent.

Examination of Urine. — Amount of urine collected during twenty-four hours, November 2, 1 o'clock P. M., to November 3, 1 o'clock P. M., 900 CC. = grains 14,510.08. Urine acid at end of thirty hours after collection. Specific gravity, 1,024 O. Thirty hours after collec-

tion in an open vessel, moderately heavy deposit of large, well-defined crystals of uric acid, very light orange color.

Plate No. XX.,[1] Figure 3, represents the color of the urine.

ANALYSIS OF URINE, NO. 30.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	14,510.08	
Urea	498.96	34.38
Uric acid	14.87	1.02
Free acid	41.58	2.86
Phosphoric acid	40.47	2.78
Equivalent of phosphorus in phosphoric acid	17.79	1.22
Sulphuric acid	22.84	1.57
Equivalent of sulphur in sulphuric acid	9.13	0.629
Chloride of sodium	181.56	1.25
Equivalent of chlorine in chloride of sodium	110.02	7.58

November 6. — Eight o'clock P. M. Pulse, 96. Respiration, 16. Temperature of hand, 37.2° C. (98.9° F.). Temperature of axilla, 37.4° C. (99.3° F.). Tongue clean and moist. Good complexion, and lively spirits. Appetite good. Gangrene all removed from wound. Healthy, red, granulating surface of wound. This case terminated favorably.

CASE XXXI. J. W. Souby, wounded 16th of September at Chickamauga; flesh-wound of thigh. Transferred to Second Georgia Hospital, Augusta, Ga. Gangrene appeared in wound, and was arrested by the mode of treatment usual in this hospital.

Case XXXI. Illustrating the changes of the temperature and urine in hospital gangrene.

November 3. — Wound in thigh rapidly improving, and filling up with healthy granulations. Patient cheerful, with good complexion and excellent appetite. Walking about.

ANALYSIS OF URINE, NO. 31.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	26,168.57	
Urea	479.86	18.33
Uric acid	6.45	0.24
Free acid	26.51	1.01
Phosphoric acid	34.34	1.31
Equivalent of phosphorus in phosphoric acid	15.10	0.57
Sulphuric acid	33.35	1.27
Equivalent of sulphur in sulphuric acid	13.34	0.509
Chloride of sodium	207.09	7.91
Equivalent of chlorine in chloride of sodium	125.49	4.79

[1] Omitted.

Examination of Urine. — Amount of urine collected during twenty-four hours, November 2, 1 P. M., to November 3, 1 P. M., 1,640 CC. = grains 26,168.57. Specific gravity, 1,013.5. Slightly acid thirty hours after collection; at the end of this time no deposit, only slight turbidness. Straw-colored and abundant like the urine of health. Plate No. XX.,[1] Figure 4, represents the color of the urine.

Case XXXII. Illustrating the changes of the temperature and urine in hospital gangrene.

CASE XXXII. George J. Robison, 17th Mississippi Regiment, Company B. Age, twenty-one. Height, five feet four inches. Weight, one hundred and twenty pounds in health. Small man, but firmly built and healthy. Wounded by minie-ball in calf of leg, three and one half inches above the heel, on the 19th of September, 1863, at Chickamauga. Transferred to Second Georgia Hospital, Augusta, Ga., on the 30th of September. Had fever at the railroad depot before entering the hospital. The fever continued three days before the appearance of gangrene in the wound, and was ushered in by a slight chill. Bowels costive, not having been moved for one week before the commencement of the fever. Patient states that the wound commenced paining him in the evening, about eighteen hours before he noticed the rise of the fever. Lay at the railroad depot in the car-shed four and a half days. During this time his wound was repeatedly dressed by the ladies of Augusta. Gangrene appeared October 3, and under the local and constitutional treatment employed in gangrene at this hospital, gradually disappeared.

November 3. — Appetite good; spirits cheerful; complexion clear. The gangrene disappeared from the wound several days ago, and it presents a red, florid, granulating, healthy surface. Wound four inches in its long diameter, and two and one half inches in its short diameter. Discharges healthy, laudable pus. Heel drawn up by the contraction of the gastrocnemius muscle, which has been extensively denuded and destroyed by the gangrene. The disability appears to be permanent.

ANALYSIS OF URINE, NO. 32.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours.	19,895.50	
Urea	423.50	21.28
Uric acid	2.95	0.148
Free acid	25.98	1.30
Phosphoric acid	36.19	1.82
Equivalent of phosphorus in phosphoric acid	15.91	0.79
Sulphuric acid	26.58	1.33
Equivalent of sulphur in sulphuric acid	10.63	0.53
Chloride of sodium	192.50	9.62
Equivalent of chlorine in chloride of sodium	116.65	5.86

[1] Omitted.

Examination of Urine. — Amount of urine collected during twenty-four hours, November 2d, 1 P. M., to November 3d, 1 P. M., 1,250 CC. = grains 19,895.50. Specific gravity, 1,015. Reaction thirty hours after collection, acid, no deposit. Light yellow color, like that of health. (See Plate No. XX.,[1] Figure 5.)

Several important facts relating to the organic chemistry of this disease, and bearing upon the pathology and treatment, are established by the preceding observations, in addition to those already generalized in the propositions contained in the first pages of this chapter.

The following table presents a consolidated classification of my observations illustrating the relations of the gangrenous inflammation to the changes of the pulse, respiration, temperature, and urine.

[1] Omitted.

TABLE OF OBSERVATIONS UPON THE CHANGES OF THE PULSE, RESPIRATION, AND TEMPERATURE, AND THE PHYSICAL AND CHEMICAL PROPERTIES AND CONSTITUTION OF THE URINE IN HOSPITAL GANGRENE, BY JOSEPH JONES, M. D., SURGEON P. A. C. S.

Name of Patient and Number of Case as reported.	State of Wound and Result.	Date.		Pulse, Respiration, and Temperature.			Physical Properties and Chemical Constituents of Urine.										
		Year and Day of Month.	Hour of Day.	Pulse.	Respiration.	Temperature of Mouth.	Temperature of Axilla.	Amount of Urine passed during 24 hours. Grains.	Color of Urine.	Specific Gravity.	Urea. Grains.	Uric Acid. Grains.	Urea. Grains.	Phosphoric Acid. Grains.	Sulphuric Acid. Grains.	Chlorine of Sodium. Grains.
Ira Parker, Confederate soldier, Company G, 1st Texas Regiment. Age, 23; light hair, gray eyes; height, 5 feet 8 inches. CASE XLVI.	Wounded Sept. 19, 1863, in right leg. Gangrene attacked the wound Oct. 1st. Nov. 2, patient pale and anæmic. Hospital gangrene in wound. Nov. 6, wound covered with dark, unhealthy slough. Nov. 9, had a chill at ten o'clock, p. m. Nov. 10, patient nervous and restless. Nov. 11, symptoms of pyæmia well marked; pulse small and feeble. Nov. 17, died at five o'clock, p. m.	1863 Nov. 2	p. m.	114	18	101.4	104.9	18,407	Deep orange	1,023.5	655	10.4	39.4	61.4	64.9	70.6
		3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		4	–	96	18	98.8	98.8	–	–	–	–	–	–	–	–	–
		5	9 A. M.	84	18	99	100.7	–	–	–	–	–	–	–	–	–
		6	4 P. M.	100	18	101.1	102.9	–	–	–	–	–	–	–	–	–
		6	9 P. M.	108	16	99.2	103.6	–	–	–	–	–	–	–	–	–
		7	9 A. M.	96	18	99.7	102.2	–	–	–	–	–	–	–	–	–
		7	5 P. M.	108	18	99.3	102.9	–	–	–	–	–	–	–	–	–
		9	9½ A. M.	96	18	99.1	100.7	–	–	–	–	–	–	–	–	–
		9	8 P. M.	100	18	99	102.3	16,080	Deep orange red	1,021	492	11.02	60	67.2	90	69.1
		10	10 A. M.	100	16	–	–	–	–	–	–	–	–	–	–	–
		10	8 P. M.	112	–	–	–	8,847	Deep pink red	1,024	498	10.30	21	85.5	17.0	8.4
		15	6 P. M.	120	26	101.6	102.2	–	–	–	–	–	–	–	–	–
		16	9 A. M.	120	–	–	–	11,278	Deep pink red	1,028	491	11.02	29.6	86.6	20.4	2.15
		17	11 A. M.	120	–	–	–	–	–	–	–	–	–	–	–	–
J. B. Carrico, Confederate soldier. Age, 29; height, 6 feet 1 inch; weight in health, 186 lbs. Corporal in Sedem's battery. CASE XLVII.	Wounded at Jonesboro', Sept. 1, 1864, left leg. Gangrene attacked wound on the 13th of Sept. Oct. 3, gangrene progressing slowly. Oct. 7, patient had a chill, followed by diarrhœa. Oct. 6, symp-	1864 Oct. 3	5 P. M.	101	26	100.4	105.8	22,271	Deep scarlet	1,010	409	5.6	32.34	36.2	22.6	25.8
		4	9 A. M.	94	28	98	98.3	–	–	–	–	–	–	–	–	–
		4	5 P. M.	108	26	102.2	104.4	–	–	–	–	–	–	–	–	–
		5	9 A. M.	106	–	–	–	–	–	–	–	–	–	–	–	–
		6	9 A. M.	110	28	100.4	102.2	–	–	–	–	–	–	–	–	–
		6	6 P. M.	96	26	99	105.8	–	–	–	–	–	–	–	–	–
		7	9 A. M.	96	–	–	–	–	–	–	–	–	–	–	–	–
		8	9 A. M.	128	–	–	–	–	–	–	–	–	–	–	–	–

	toms of pyæmia well marked. Oct 9, patient died at nine o'clock, P. M.															
		1864														
W. J. Cloar. Age, 24; height, 6 feet; weight, 180 lbs. Company A, 33d Regiment, Tennessee Vols., Sthall's Brigade, Cheatham's Division. CASE XLVIII.	Wounded at Jonesboro', Ga., Aug. 31, 1864. Both legs wounded. Right leg amputated at upper third on field of battle. Gangrene attacked the wound Sept 21. Oct. 2, gangrene progressing slowly. Patient feeble, with hectic flush and fever; restless and nervous. Oct. 5, had a chill. 6th, chills continued; pyæmia well marked. Died Oct. 12, 11 A. M.	Oct. 1	12 M.	100	20	102.2	102.6	–	–	–	–	–	–	–	–
		2	9 A. M.	95	28	102.2	–	–	–	–	–	–	–	–	–
		2	12 M.	120	30	99	100.4	13,864	Deep brownish red	1,024	682	10.32	38.4	68.8	49.8	13.2
		3	9 A. M.	100	24	101.1	101.3	–	–	–	–	–	–	–	–	–
		3	5 P. M.	104	28	100.2	104.2	–	–	–	–	–	–	–	–	–
		4	10 A. M.	102	28	95.9	104.4	–	–	–	–	–	–	–	–	–
		4	6 P. M.	116	30	100.4	105.5	–	–	–	–	–	–	–	–	–
		5	10 A. M.	102	24	99.4	100.4	–	–	–	–	–	–	–	–	–
		5	4½ P. M.	122	26	100.4	104.72	14,488	Deep brilliant scarlet	1,022.5	693	14.4	48.5	72	40.3	41.5
		6	9 A. M.	110	28	97.4	100.4	9,376	Deep brilliant scarlet	1,027	462.6	9.04	35.7	53.5	29.2	Trace
		6	6 P. M.	120	28	101.5	104	–	–	–	–	–	–	–	–	–
		7	9 A. M.	105	26	100.4	102.2	–	–	–	–	–	–	–	–	–
		7	6 P. M.	110	28	104.7	105.8	–	–	–	–	–	–	–	–	–
		1863														
John Kemp, sergeant, 11th Regiment, Tennessee Vols. Age, 20; height, 6 feet; weight, 160 lbs. CASE III.	Wounded 19th of Sept., at Chickamauga. Ball wounded foot. Gangrene attacked wound, Nov. 4, 1863. 10th, gangrene spreading. 16th, wound improving. 17th, swelling subsided; wound granulating.	Nov. 10	5 P. M.	100	28	85	102.8	–	–	–	–	–	–	–	–	–
		11	8 A. M.	98	28	90	100	–	–	–	–	–	–	–	–	–
		12	9 A. M.	100	28	93.5	100.5	–	–	–	–	–	–	–	–	–
		12	4½ P. M.	120	28	103	103.5	–	–	–	–	–	–	–	–	–
		13	9½ A. M.	102	28	93.5	102	23,496	Deep orange	1,018.5	609	16.14	23.6	40.6	37.6	130.8
		14	4 P. M.	120	28	99	102	–	–	–	–	–	–	–	–	–
		15	10½ A. M.	100	28	85	99	–	–	–	–	–	–	–	–	–
		16	8½ A. M.	100	28	92	100	–	–	–	–	–	–	–	–	–
		16	5 P. M.	100	28	96	99.5	–	–	–	–	–	–	–	–	–
		17	9½ A. M.	100	28	98	100	–	–	–	–	–	–	–	–	–
		1864														
W. J Black, Confederate soldier. Age, 46; height, 5 feet 9 inches; weight, 160 lbs.; black hair and eyes. CASE VII.	Sept. 22, poisoned his thumb in nursing cases of hospital gangrene. Oct. 5, gangrene progressing.	Oct. 5	–	More frequent in afternoon and ev'ning		Increased in the afternoon and evenings and diminished in the mornings.		7,915	Deep brown, inclining to blackish-red	1,028	369	5.88	26.41	33.2	29.2	11.7
		1864														
Thomas Paine, 4th Mississippi Regiment, C.S.A.	Wounded at Atlanta, Ga., Aug. 17, 1864. Fragment of	Sept. 30	P. M.	120	20	105.7	106.1	–	–	–	–	–	–	–	–	–
		Oct. 1	8½ A. M.	105	16	101.9	102.6	–	–	–	–	–	–	–	–	–
		1	8 P. M.	134	21	–	–	–	–	–	–	–	–	–	–	–

TABLE OF OBSERVATIONS UPON HOSPITAL GANGRENE.—(*Continued.*)

Name of Patient and Number of Case as reported.	State of Wound and Result.	Date. Year and Day of Month.	Date. Hour of Day.	Pulse, Respiration, and Temperature. Pulse.	Respiration.	Temperature of Hand.	Temperature of Axilla.	Physical Properties and Chemical Constituents of Urine. Amount of Urine collected during 24 Hours, Grains.	Color of Urine.	Specific Gravity.	Urea, Grains.	Uric Acid, Grains.	Free Acid, Grains.	Phosphoric Acid, Grains.	Sulphuric Acid, Grains.	Chloride of Sodium, Grains.
		1864														
Age, 22; height, 5 feet 10 inches; weight, 150 lbs.; brown hair, grayish-black eyes. CASE VIII.	shell struck flesh of thigh. Hospital gangrene attacked the wound on the 27th of August, and destroyed considerable portions of tissues of thigh.	Oct. 2	8 A. M.	116	22	85.1	100.80	23,891	Bright red	1,011.5	635	3	24.2	50.8	32.7	110.8
		2	8 P. M.	114	22	103.5	104.1	–	–	–	–	–	–	–	–	–
		3	8 A. M.	106	24	93.2	100.8	–	–	–	–	–	–	–	–	–
		3	8 P. M.	101	17	100.4	100.8	–	–	–	–	–	–	–	–	–
		4	8 P. M.	101	17	100.4	100.8	Portion lost, 10,322	Deep orange	1,012	210	1.3	24.2	6	8.4	40
		5	8 A. M.	112	26	102.2	104.1	–	–	–	–	–	–	–	–	–
		5	8 P. M.	104	20	99.2	102.2	13,601	Reddish orange	1,015	347	4.25		18.3	8.4	19.6
		6	8 A. M.	112	24	94.1	101.5	–	–	–	–	–	–	–	–	–
		11	8 P. M.	126	21	104.4	104.75	–	–	–	–	–	–	–	–	–
		18	11 A. M.	116	–	–	–	27,479	Light orange	1,014	664	8.28	13.2	19.12	27.2	17.3
		19	10 A. M.	104	–	–	100.8	14,353	Light orange	1,024	438	10.14	17.2	22.4	28.2	61
		22	8 P. M.	–	–	93.3	100.8	–	–	–	–	–	–	–	–	–
		1864														
Arnold Nowell, private, 57th Alabama Regiment. Age, 37; weight, 158 lbs.; black hair and black eyes. CASE XII.	Wounded July 20, 1864, near Atlanta, in arm. Gangrene attacked wound 20th Aug., and rapidly destroyed the tissues. Patient died Oct. 4th.	Oct. 2	2 P. M.	Very feeble, 100	21	102.2	102.6	–	–	–	–	–	–	–	–	–
		2	9 A. M.	100	18	99	101.3	Considerable portion lost, 5,581	Deep orange-red	1,013	177	2.45	40.7	16.6	5.16	5.3
		3	12 M.	124	24	100.4	102.2	–	–	–	–	–	–	–	–	–
		4	6 P. M.	120	28	100.8	102.6	–	–	–	–	–	–	–	–	–
		1863				F.	F.									
E. J. Wainwright, Confederate soldier, Florida cavalry. Age, 28; height, 5 feet 9 inches; weight, 175 lbs. CASE XVII.	Wounded Sept. 19, 1863. Piece of shell imbedded itself in left buttock. Fragment of shell removed on the field. Oct. 6, gangrene attack'd wound and destroyed large	Nov. 3	–	–	–	–	–	19,507	Orange red	1,016	526	13.8	16.9	43.5	32.2	140
		6	9 A. M.	80	16	88	97.5	–	–	–	–	–	–	–	–	–
		6	9 P. M.	98	18	101.1	102.5	–	–	–	–	–	–	–	–	–
		7	9 A. M.	86	18	–	–	–	–	–	–	–	–	–	–	–
		7	5 P. M.	96	18	97.1	99.3	–	–	–	–	–	–	–	–	–
		8	9 A. M.	80	18	88.1	98.9	–	–	–	–	–	–	–	–	–
		9	9½ A. M.	80	18	89.9	96.8	–	–	–	–	–	–	–	–	–
		9	8 P. M.	98	–	84	99.1	–	–	–	–	–	–	–	–	–

| Names of cases. | | |

TABLE OF OBSERVATIONS UPON HOSPITAL GANGRENE.—(*Continued.*)

Name of Patient and Number of Case as reported.	State of Wound and Result.	Date.		Pulse, Respiration, and Temperature.				Physical Properties and Chemical Constituents of Urine.								
		Year and Day of Month.	Hour of Day.	Pulse.	Respiration.	Temperature of Hand.	Temperature of Axilla.	Amount of Urine collected during 24 Hours, Grains.	Color of Urine.	Specific Gravity.	Urea, Grains.	Uric Acid, Grains.	Free Acid, Grains.	Phosphoric Acid, Grains.	Sulphuric Acid, Grains.	Chloride of Sodium, Grains.
Sergeant J. J. Lamb, Confederate soldier, 5th Alabama Vols. Age, 21; height, 5 feet 10 inches; weight, 165 lbs. Reddish hair and gray eyes. CASE XX.	Wounded Sept. 19, 1863, in left leg, three inches below knee on anterior side. Wound attacked by hospital gangrene Oct. 9. Oct. 16, gangrene still extending; wound five inches in diameter; constitutional symptoms well marked; several gangrenous spots appearing upon different parts of the leg. 25th, wound encircles the leg, with the exception of a small strip of skin.	1863 Oct. 30	11½ A. M.	94	20	98.3°	100.3°	12,966	Deep orange red	1,017	374	10.58	–	12.47	20	31
		Nov. 1	11 A. M.	88	–	94	101	–	–	–	–	–	–	–	–	–
		1	6 P. M.	112	–	95	102	–	Red	–	–	–	–	–	–	–
		5	6 P. M.	112	20	95	102	17,957	–	1,018	551	21.16	35.7	34.6	23.9	98.3
		10	4 P. M.	100	–	73	99	–	–	–	–	–	–	–	–	–
		11	4 P. M.	104	–	79	101	–	–	–	–	–	–	–	–	–
		12	10 A. M.	96	14	73	98	–	–	–	–	–	–	–	–	–
		12	5 P. M.	100	–	82	101	–	–	–	–	–	–	–	–	–
		13	8 A. M.	98	–	74	99	–	–	–	–	–	–	–	–	–
B. P. Talley, Lieutenant, 20th Texas cavalry regiment. Age, 21; gray eyes, light hair. CASE XXI.	Wounded Sept. 19, 1863, in posterior fleshy portion of right thigh, midway between the knee and hip joint. Gangrene set in on the 18th of Oct. 21st, fever; destruction of tissues goes on slowly. Oct. 31, wound dry, inflamed, and painful.	1863 Oct. 31	–	100	–	–	–	12,012	Deep or. red	1,018	404.2	9.32	28.87	43.89	25	19.3
		Nov. 4	10 A. M.	96	–	–	–	–	–	–	–	–	–	–	–	–
		5	10 A. M.	98	–	–	–	20,360	Deep or. red	1,018	785.4	22	40.2	51	53.3	64.7
		5	4½ P. M.	108	–	–	–	–	–	–	–	–	–	–	–	–
		7	10 A. M.	96	–	–	–	–	–	–	–	–	–	–	–	–
		7	4 P. M.	108	–	103	103.5	–	–	–	–	–	–	–	–	–
		9	10 A. M.	96	–	94	101.75	–	–	–	–	–	–	–	–	–
		11	10 A. M.	94	18	90	99	–	–	–	–	–	–	–	–	–
		12	4 P. M.	108	–	103	103.5	–	–	–	–	–	–	–	–	–
		13	10 A. M.	90	–	80	100	–	–	–	–	–	–	–	–	–
		14	10 A. M.	100	–	95	100	–	–	–	–	–	–	–	–	–
		15	10 A. M.	100	–	85	101	–	–	–	–	–	–	–	–	–

	Nov. 4, slight improvement in wound.	15	4 P. M.	100	–	100	102	–	–	–	–	–	–	–	–	–	–
	7th, wound discharges unhealthy pus.	16	9 A. M.	100	–	83	99	–	–	–	–	–	–	–	–	–	–
	11th, still gangrenous. 15th, some healthy granulations.	16	5 P. M.	100	–	97	100	–	–	–	–	–	–	–	–	–	–
	16th, wound four inches in diameter, and florid.																
		1863															
R. D. Beck, Company G, 1st Regiment Florida Cavalry. Age, 29; dark hair, gray eyes, dark complexion.	Wounded Sept. 20, 1863, in foot. Gangrene attacked the wound Oct. 26. Oct. 30, patient restless and nervous; suffers extreme pain; pulse feeble and rapid. Gangrene continued to spread until 7th November.	Oct. 30	–	–	–	Fever	Fever	8,817	Deep red	1,017	279	6.07	11.16	12.87	18.41	12.7	
		Nov. 5	–	Rapid and feeble	–	Fever	Fever	–	–	1,010	327	9.15	24.14	29.1	22.6	36.2	
CASE XXII.																	
		1863															
J. C. Carter, Company I, 6th Florida Regiment. Light hair and eyes; fair complexion. Age, 22.	Wounded Sept. 19, 1863. Musket-ball entered radial side of fore-arm. Oct. 3 and 4, hemorrhage from wound. Oct 7, wound attacked by hospital gangrene. The gangrene progressed steadily up to the 28th, slowly destroying the tissues, until the wound was three inches in diameter. Nov. 3 and 4, severe hemorrhage from the wound.	Nov. 10	4½ P. M.	120	18	99	101.5	23,439	Orange	1,009	364.9	11.61	20.4	19.9	15.1	81	
		11	9 A. M.	108	18	92.5	100	–	–	–	–	–	–	–	–	–	–
		12	10 A. M.	100	18	98	100.25	–	–	–	–	–	–	–	–	–	–
		14	9½ A. M.	100	18	97	100	–	–	–	–	–	–	–	–	–	–
		15	11 A. M.	100	18	91	100	–	–	–	–	–	–	–	–	–	–
CASE XXIII.																	
		1863				F.	F.										
Francis Quinn, 13th Louisiana Vols. Age, 39; dark hair, dark complexion, gray eyes.	Wounded Sept. 20, 1863. Ball passed through muscles of chest, and emerged from axilla. Hospital gangrene attacked the wound on the	Oct. 31	–	–	–	–	–	16,234	Orange red	1,014	361.2	16.86	26.7	28.2	18.8	62.8	
		Nov. 1	9 A. M.	100	–	87.5	100	–	–	–	–	–	–	–	–	–	–
		1	5 P. M.	104	–	88.5	101	–	–	–	–	–	–	–	–	–	–
		4	10 A. M.	94	–	89	100	–	–	–	–	–	–	–	–	–	–
		5	–	94	–	89	100	23,450	Orange red	1,013	486.7	16.89	47.5	31.6	21.6	208.7	
		9	9 A. M.	94	–	91	101	–	–	–	–	–	–	–	–	–	–
CASE XXIV.		9	4½ P. M.	100		93	101.5	–	–	–	–	–	–	–	–	–	–

TABLE OF OBSERVATIONS UPON HOSPITAL GANGRENE.—(*Continued.*)

Name of Patient and Number of Case as reported.	State of Wound and Result.	Date. Year and Day of Month.	Date. Hour of Day.	Pulse, Respiration, and Temperature. Pulse.	Respiration.	Temperature of Back.	Temperature of Axilla.	Physical Properties and Chemical Constituents of Urine. Amount of Urine collected during 24 Hours, Grains.	Color of Urine.	Specific Gravity.	Urea, Grains.	Uric Acid, Grains.	Free Acid, Grains.	Phosphoric Acid, Grains.	Sulphuric Acid, Grains.	Chlorine of Sodium, Grains.
		1863														
	12th of Oct. Oct. 25, the gangrene has continued to progress, with fever every evening. Oct. 31, gangrene arrested. Nov. 1, wound still gangrenous. 5th, gangrene arrested.	Nov. 10	9½ A. M.	94	–	99	99	"	"	"	"	"	"	"	"	"
		12	3½ P. M.	100	–	99	101	"	"	"	"	"	"	"	"	"
		1864														
A. M. McGowan, Lieut. 3d Confederate Mississippi Battalion. Light hair, fair complexion, blue eyes. Age, 29.	Wounded at Atlanta, Aug. 31, 1864. Minie-ball struck the outer portion of the lower third of left thigh, about five inches above the knee joint, and passed through the muscles without injuring the bone. Gangrene attacked the wound Sept. 10, and continued to spread until it denuded the muscles of the thigh. Sufferings of the patient intense, and attended with quiverings of all the muscles. Nov. 5, wound twelve inches in diam-	Oct. 6	6 A. M.	96	22	95.4	100.4	"	"	"	"	"	"	"	"	"
		6	6 P. M.	110	28	95	102.2	"	"	"	"	"	"	"	"	"
		7	8 A. M.	116	22	93.2	100.4	"	"	"	"	"	"	"	"	"
		7	8 P. M.	118	24	100.4	104	"	"	"	"	"	"	"	"	"
		8	9 A. M.	110	16	99.5	101.5	"	"	"	"	"	"	"	"	"
		8	8 P. M.	126	22	97.6	99.4	"	"	"	"	"	"	"	"	"
		9	8 A. M.	122	18	93.2	97.5	"	"	"	"	"	"	"	"	"
		10	9 A. M.	124	16	89.6	99.4	"	"	"	"	"	"	"	"	"
		10	8 P. M.	124	21	97.5	100.4	"	"	"	"	"	"	"	"	"
		11	8 A. M.	126	18	89.7	97.3	"	"	"	"	"	"	"	"	"
		11	8 P. M.	112	18	98.6	101.2	"	"	"	"	"	"	"	"	"
		18	–	–	–	–	–	6,419.7	Deep red	1,019	203.2	4.96	13.86	11.08	11.53	18.48
		19	–	–	–	–	–	11,240	Deep red	1,020	324.5	9.80	29.04	41.05	20.04	33.34

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TABLE OF OBSERVATIONS UPON HOSPITAL GANGRENE.—(*Continued.*)

Name of Patient and Number of Case as reported.	State of Wound and Result.	Date.		Pulse, Respiration, and Temperature.				Physical Properties and Chemical Constituents of Urine.									
		Year and Day of Month.	Hour of Day.	Pulse.	Respiration.	Temperature of Skin.	Temperature of Axilla.	Amount of Urine excreted within 24 Hours. Grains.	Color of Urine.	Specific Gravity.	Urea. Grains.	Uric Acid. Grains.	Free Acid. Grains.	Phosphoric Acid. Grains.	Sulphuric Acid. Grains.	Chlorine of Sodium. Grains.
Thomas Benton Childers, 1st Regiment Alabama Vols. CASE LI.	Has been nursing gangrene cases in the hospital; was suffering at the time with an eruption upon both feet, which caused him to scratch the instep of his feet. The gangrenous matter was conveyed from the wounds which he dressed, in this manner, to his feet. The gangrene spread steadily in both feet, destroying the limbs and muscles, and inflicting great pain. Oct. 6.	1864 Oct. 17 19						6,000 10,001	Orange Orange	1,016.6 1,018.6	100 211.6	0.09 0.03	6.39 6.15	2.8 2.03	8.85 10.01	9.9 8.04
F. M. Sanches, Confederate soldier. CASE XXV.	Wounded at battle of Chickamauga. Flesh wound of shoulder. Oct. 18, hospital gangrene attacked wound of entrance. Constitutional symptoms well marked. Oct. 20, has fever; wound gangrenous. Appetite poor.	1863 Oct. 20	-	-	-	-	-	12,820	Orange red	1,018	468	10.45	33.88	33.51	39.6	49.9

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TABLE OF OBSERVATIONS UPON HOSPITAL GANGRENE.—(*Continued.*)

Name of Patient and Number of Case as reported.	State of Wound and Result.	Date. Year and Day of Month.	Date. Hour of Day.	Pulse, Respiration, and Temperature. Pulse.	Respiration.	Temperature of Hand.	Temperature of Axilla.	Physical Properties and Chemical Constituents of Urine. Amount of Urine collected during 24 Hours, Grains.	Color of Urine.	Specific Gravity.	Urea, Grains.	Uric Acid, Grains.	Free Acid, Grains.	Phosphoric Acid, Grains.	Sulphuric Acid, Grains.	Chloride of Sodium, Grains.
Bennet Bushing, Confederate soldier, 25th Texas Regiment. Native of Poland. Age, 39; height, 5 feet 6 inches; weight, 163 lbs.; gray eyes; black hair. CASE XXVIII.	Wounded Sept. 19, 1863. Fragment of shell struck anterior surface of leg two inches above ankle joint. Gangrene appeared Oct. 6, and continued up to Nov. 2, when a slight improvement in the wound was manifest. Nov. 8, gangrene disappeared and the wound granulating.	1863 Nov. 3	–	–	–	°	°	24,895	Deep reddish yellow	1,012	432.4	7.38	18	30.7	17.12	180
		6	9½ A.M.	94	16	95.3	102.3	–	–	–	–	–	–	–	–	–
		6	8 P.M.	100	16	98.6	101.1	–	–	–	–	–	–	–	–	–
		7	9 A.M.	88	16	97.1	101.1	–	–	–	–	–	–	–	–	–
		7	5 P.M.	88	16	98.6	102.3	–	–	–	–	–	–	–	–	–
		8	9 A.M.	80	16	96.9	99.3	–	–	–	–	–	–	–	–	–
		9	9 A.M.	84	16	92.1	96.9	–	–	–	–	–	–	–	–	–
		9	5 P.M.	84	–	93.7	100.7	–	–	–	–	–	–	–	–	–
		10	9 A.M.	80	16	93.2	98.9	–	–	–	–	–	–	–	–	–
P. C. Kenton, Confederate soldier, 1st Tennessee Regiment. Age, 37; height, 5 feet 8 inches; brown hair. CASE XXIX.	Wounded Sept. 19, 1863, in left leg; gangrene attacked wound Oct. 7. Nov. 2, gangrene disappeared from wound. Appetite good.	1863 Nov. 3	–	–	–	–	–	22,398	Yellow	1,009	303.6	5.44	21.69	14.76	9.66	13.02
I. W. Smith, 41st Tennessee Regiment. Age, 21; height, 5 feet 6 inches; weight 135 lbs. CASE XXX.	Wounded Sept. 19, 1863, through fleshy part of arm. Gangrene appeared 10th of Oct., and arrested on 24th Oct. Nov. 3, wound in good condition; granulating.	1863 Nov. 3	–	–	–	–	–	14,510	Yellow	1,024	498	14.87	41.58	40.47	22.84	181

J. W. Souby, Confederate soldier. CASE XXXI.	Wounded Sept. 16, 1863. Flesh-wound of thigh. Gangrene appeared Oct. 10; was arrested in the course of ten days. Nov. 3, wound granulating.	1863 Nov. 2	-	-	-	-	-	26,168	Light yellow	1,013.5	479	6.45	26.51	34.34	33 35	207.09
George R. Robison, 17th Mississippi Regiment, C. S. A. Age, 21; height, 5 feet 4 inches; weight, 120 lbs. CASE XXXII.	Wounded by minie-ball in calf of leg, Sept. 19, 1863. Gangrene attacked the wound on the 3d of Oct., and under the usual local and constitutional treatment, disappeared. Nov. 5, appetite good, spirits cheerful, complexion clear. Gangrene disappeared from the wound several days ago, and it presents a florid, healthy appearance.	1863 Nov. 3	-	-	-	-	-	19,895	Light yellow	1,015	423.5	2.95	25.98	36.19	26 58	192.5
M. D. Davis, 22d Regiment Alabama Vols. Age, 20; height, 5 feet 7 inches; weight in health, 145 lbs. CASE XXXVI.	Wounded June 22, 1864, on Powder Springs road, near Marietta, Ga.; fragment of shell grazed the external surface of the middle of the right thigh. Gangrene appeared Aug. 1, and denuded a large portion of the muscles. Oct. 2, patient greatly reduced; gangrene removed and wound granulating. Oct. 18 and 19, convalescent, and wound extensive but healthy.	1864 Oct. 18	-	-	-	-	-	28,752	Light yellow	1,016	693	9.36	19.4	11.08	34.2	110.8
		19	-	-	-	-	-	39,090	Light yellow	1,016	512	4.81	28.49	11.89	33.4	102

The preceding observations establish the following conclusions: —

1. The local manifestations of hospital gangrene are attended by febrile actions in the general system.

The local manifestations of hospital gangrene, attended by febrile actions in the general system. Characteristics of the fever of hospital gangrene.

The fever of hospital gangrene, like that accompanying other diseases, is characterized by increase of heat, increased chemical change, and increased elimination of those substances, as uric acid, phosphoric acid, sulphuric acid, and extractive and coloring matters, which result from the destructive metamorphosis of the solids and fluids.

The fever appeared, in many cases of hospital gangrene, before the wounds had actually assumed the gangrenous state, with swollen, everted edges, and gray, sloughing surface; and after careful investigation, it appeared to be more reasonable, at this stage of the disease, to consider the fever as the resultant and necessary accompaniment of the earliest changes in the wound, than as the cause of the gangrenous inflammation. Simultaneously with the development of the fever, and the constitutional disturbances characterized by loss of appetite, depression of spirits, constipation of the bowels, and such an enfeebled, irritative action of the circulatory apparatus as denoted a depression of the vital, nervous, and muscular forces, certain local changes were noted in the wounds, as the transformation of the moist fluid granulations into a dark-red glazed surface, the marked change, or total suppression of the natural discharges of pus, increased heat and pain, and an increased congestion of the blood-vessels in and around the wound.

2. The fever of hospital gangrene appears to be manifestly the result of the action of an organic poison.

The fever of hospital gangrene results from the action of an organic poison. Facts sustaining this proposition.

This proposition is sustained by the facts clearly established by the preceding investigation, namely, that gunshot wounds are not necessarily attended by fever; that the fever accompanies or follows the supervention of hospital gangrene in those cases of gunshot wounds which, up to this period, had been unaccompanied by febrile excitement; and finally, that the complete separation of the ragged, spongy, gray sloughs, and the appearance of healthy granulations and pus in the wound, and the arrest of the further progress of the gangrene, are certainly attended, if not preceded, by corresponding improvements in the constitutional symptoms.

After the removal of the gangrene, and the establishment of

granulation and suppuration, the pulse becomes fuller and slower, the diurnal variations of temperature less, the normal relations between the temperature of the extremities and central organs are reëstablished, the capillary circulation in the extremities becomes more active, and the appetite improves, the complexion loses its leaden, dusky, unhealthy hue, the eye expresses hope and life, and the distressed countenance becomes cheerful: corresponding changes are observed in the urinary excretion; as the wound improves, the urine progressively loses its high color and the febrile characters, and approaches by gradual degrees to the standard of health. No crisis or sudden change is observed in the urine during the period of convalescence, but the changes in the excretion correspond with the gradual changes of the wound. In this respect, all the symptoms correspond, in that they all gradually and progressively improve, without any marked or sudden changes as in certain diseases, as for example, in malarial fever.

The favorable changes just indicated, will frequently take place, even where a most extensive surface is exposed and raw, as a large portion of the back, or of the buttock, or of the thigh, six or eight inches in diameter. The fact that all the constitutional symptoms may improve, even before the diminution of the size of the wound, and whilst a large raw surface of muscles, nerves, and blood-vessels and bones remain exposed, demonstrates conclusively that the constitutional disturbances are not due exclusively or even in great measure to the local irritation of the nerves exposed by the gangrene.

Where, on the other hand, hospital gangrene progresses unfavorably, the constitutional symptoms become progressively more grave, and the fatal termination is generally announced by a feeble, rapid pulse, extreme prostration, twitching of the tendons, vomiting, hiccough, involuntary dejections, and ofttimes coma.

In this disease, death unquestionably results in many cases from the absorption of the gangrenous matter. In this case, the immediate cause of death is often profuse and uncontrollable diarrhœa. The absorbed gangrenous matter may also in certain cases excite mortification of important internal organs. Such a change may take place rapidly, and without the manifestation of any symptoms during the life of the patient which indicate the presence of the disease.

We conclude, therefore, from these well established facts, that in every case of hospital gangrene which terminates favorably or unfavorably, the character and extent of the constitutional dis-

turbances are due in a great measure to the absorption of deleterious poisonous matters from the wound.

Characteristics of the febrile state of hospital gangrene.

3. The febrile state of hospital gangrene is characterized by increased chemical change in the blood and textures, increased development of heat above the standard of health, marked diurnal variations of temperature, great irritability and feebleness of the general circulation, and imperfect and feeble capillary circulation, as manifested by the marked difference of temperature between the trunk and extremities, and the inability of the extremities to maintain a definite temperature, and withstand the effects of external cold.

It will be seen from the table, that the periodical elevations and depressions of temperature were intimately associated with the action of the heart. As a general rule, acceleration of the heart's action was attended with an increase of temperature; and decrease in the frequency and force of the heart's action was attended with decrease of temperature. The temperature fell to the lowest point in the mornings, when the action of the heart was slowest.

The cause of the periodic increase and decrease of temperature, must be sought in the causes which produced the disturbances in the action of the heart, and in the constitution and amounts of blood circulating through the system in given periods of time. We might conceive that the cause which excited the heart to action also excited an increased chemical change in the blood, or so depressed the force which is supposed in health to regulate the waste of tissue, that the elements were allowed to enter into more rapid chemical changes than usual, or that the relations of the vital, nervous, and physical forces were so disturbed that instead of the generation of nervous force or electricity, there was only the increased development of the physical force heat. As, however, the increase of heat was invariably attended with an increased circulation of the blood, which furnished the elements of chemical change, and consequently the conditions for the development of the physical forces; and further, as the increased generation of heat was attended by an increase in the products of the changes of the tissues, as manifested by the increased amounts of urea, phosphoric acid, sulphuric acid, and coloring matters excreted, it is reasonable to conclude that the elevation of temperature was not due so much to some direct action of the nervous system, or to disturbances of the correlation of the vital, nervous, and physical forces, as to the more rapid circulation of the elements of chemical change.

The question may still be asked, whether or not the disturbances in the heart's action be due to the direct action of the nervous system upon this organ? Irregularities in the heart's action may be due to various causes, as the direct action of poisonous bodies upon this organ, or upon the ganglia of the sympathetic system, or upon the constitution of the blood from which the heart derives its nutrition, or upon the cerebro-spinal system, or to all these causes at once.

Disturbances in the action of the heart, in hospital gangrene, due to a number of causes, as the direct action of the gangrenous matters upon the structures of the heart itself, or upon the blood, and sympathetic and cerebro-spinal nervous system.

It would appear that disturbances in the action of the heart, in hospital gangrene, are due to a number of causes, as the direct action of the gangrenous matter upon the structures of the heart itself, or upon the blood, or upon those portions of the sympathetic and cerebro-spinal nervous systems related to the heart.

The decomposing poisonous matters, and the products of inflammation absorbed from the gangrenous wounds, after their introduction into the circulatory system, cause derangement in the blood, and excite increased chemical change, and consequently cause an elevation of temperature. It is well known that increased heat tends to excite and accelerate the heart's action.

If the conditions remained the same, the introduction of a morbific material, capable of exciting change, into the blood, should be attended by uniform results and uniform elevations of temperature at all periods of the day. But in man the conditions are vastly varied during the different divisions of each twenty-four hours. During the day-time he is subjected to the stimulus of light, and to an increase of external temperature, all the faculties and functions are aroused and quickened, and as the day advances the heart responds to the increased excitement of the nervous and muscular systems. This periodical excitement will take place, whether the patient be in bed in the close ward, or moving about out-doors.

By long habit, the nervous system and the muscular apparatus has become accustomed to excitement and action during the working hours of the day. During the period of rest at night, the conditions are changed; the wastes of the working hours are repaired during those of repose; the withdrawal of the stimulus of light, and the removal of the incentives to nervous and muscular exertion, are attended with decreased action of the heart, and reduction of temperature. During sleep, also, the respiration is not so full, and the motion of the blood is not so perfect. The

skin also is relaxed, and the perspiration increased, and the reduction of the temperature by evaporation promoted.

The variations of the temperature at different periods of the day, in hospital gangrene, are without doubt associated with the relative states of activity of the nervous and muscular system, dependent upon the action of external stimuli.

The increased action of the heart is to be regarded in this disease as an evidence, not of increased power, but rather of debility and irritability. The patient suffering from hospital gangrene is under the action of a depressing organic poison, which alters the constitution of the blood, deranges the nutrition of all the organs, and renders the nervous system irritable and irregular in its actions. The strongest men are reduced under the action of this poison to the condition of weak, irritable children, being not only incapable of any great muscular exertion, but also of prolonged and vigorous mental effort. The exciting agencies of the day produce in this state an irritable and accelerated action of the circulation; and on the other hand, during the depressed state of sleep there is a rapid diminution of temperature, from the causes to which we have just referred.

The increased action of the heart to be regarded as an evidence, not of increased power, but of debility and irritability.

In the next place, we will proceed to draw some general comparisons between the changes of the pulse, respiration, temperature, and urine in hospital gangrene, with the phenomena of certain other diseases caused by special poisons.

COMPARISON OF THE PHENOMENA OF HOSPITAL GANGRENE WITH THOSE OF CERTAIN DISEASES CAUSED BY SPECIAL POISONS.

Pyæmia. — It will be seen, upon reference to the first three cases recorded in the preceding tables, that notwithstanding the low, depressed state, accompanied by febrile excitement, induced by the action of the poison of hospital gangrene, the supervention of a new disease, and the action of a new poison, induced an entirely new train of symptoms.

Comparison of the phenomena of hospital gangrene with those of pyæmia.

This new disease, pyæmia, engrafted upon the low, depressed state induced by hospital gangrene, was characterized by increased nervous depression and irritation, increased derangement in the general and capillary circulation, and increased derangement of the blood. The increased nervous derangement of pyæmia was attended by a marked increase of phosphoric acid in the urine; and the increased changes in the

Symptoms of pyæmia different from those of hospital gangrene.

blood, especially the destruction of the colored blood corpuscles, was attended with a great increase of the coloring matters of the urine. It is worthy of observation, that in this disease and in malarial fever, in both of which there is a more rapid destruction of the colored blood corpuscles than in any other class of diseases, chills should characterize the diseases, and form the most marked diagnostic symptoms. If such facts do not point out the nature of the cause of malarial fever, they at least sustain the belief that the disease is due to the action of a special poison, and not to mere variations of climate and changes of moisture and temperature.

Inflammatory or Surgical Fever. — A considerable proportion of gunshot wounds and injuries heal without any marked febrile excitement. As far as my observations reach, the extent and character of surgical and hectic fever corresponds with the extent and character of the inflammatory changes in and around the wound. Unhealthy and profuse suppurations, especially when the bone is involved, present the most marked and persistent elevations of temperature. In surgical fever, as well as in that accompanying hospital gangrene, we have increased chemical change in the blood, and elimination of increased amounts of urea, uric acid, phosphoric and sulphuric acids.

Inflammatory or surgical fever.

The most plausible explanation of this increase of chemical change in surgical fever is the absorption of decomposing matters, as well as the products of inflammation from the wound.

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Billroth, O. Weber, and others, have established the fact that the introduction in the blood of a healthy animal, not only of putrescent serum of blood or pus, but also of the fresh serum of blood or pus, of the fluid expressed from exudations and inflamed tissues, of dried pus, and of infusions of decomposing vegetable matter, causes fever. Moreover, a considerable febrile increase of temperature follows the injection of perfectly fresh and still warm pus into the subcutaneous connective tissue, or into the pleural cavity. And finally, the injection of fresh defibrinated blood, taken from an animal affected with a traumatic or other fever, into the blood of a healthy individual of the same species, likewise invariably produced fever, with an elevation of temperature sometimes exceeding that of an animal from which the blood was taken.

Experiments of Billroth, O. Weber, and others, illustrating this proposition.

It has even been shown, by actual experiment, that the blood of

a dog in whom fever had been excited by a fractured leg, acquires the property of exciting fever in another dog. In these experiments, the elevation of temperature took place within a few hours, and sometimes even reached its maximum within that time. Repeated injections of pus, or of serum puris, caused a continual remittent fever, marking an exacerbation after each injection.

It has also been shown, by carefully conducted experiments with healthy blood and otherwise, instituted with the design of controlling and elucidating these results, that the fever thus artificially produced is entirely independent of the local injury inflicted by the injection, which does not lead to inflammation until several days later, and that it is not caused by a simple transfusion of blood, nor by the increase of volume of the blood, nor by its dilution, nor by the coagulation of the fibrinous element.

Doctrine of John Simon, that the process of inflammation, in inflammatory fever, spreads by common material contagion.

John Simon, almost without hesitation, assumes that the process of inflammation, in inflammatory fever, spreads by common material contagion, and that the returning fluids of the inflamed part, its venous blood, and its lymph, are the agents of constitutional infection. "Yet," says this distinguished pathologist, "if a part be developing preternatural heat, and undergoing preternatural change, its venous and lymphatic outflow must of necessity represent those excesses of heat and change; and this outflow with all its belongings, material and dynamical, shedding itself without interruption into the blood, must straightway be diffused throughout the body. Not inactively we may presume; for the blood, receiving such increments of heat as the inflamed part thus contributes to its temperature, and receiving also that unwonted afflux of chemically changing material which comes from the disorganizing textures, is doubtless itself stimulated to greater activity of change. And as it circulates throughout the body, so to every texture which it supplies there is brought more than common incentive to change, till in proportion as the fever is great, every texture, according to its chemical mobility, gets to participate in the excitement, reflects as it were in a lesser scale the disorder of the inflamed part, and contributes a share to that over production of waste products and of heat which is characteristic of inflammatory fever."

Whilst, therefore, inflammatory and hectic fever is characterized in common with hospital gangrene by an increased temperature of the blood, which causes the apparent drought of the body, and acts as a universal stimulant, exciting the nervous centres and the organs dependent upon them, and exciting the heart's action by a

stimulant impression on the endocardium, and the muscles, and the cardiac ganglia; and whilst both diseases are attended by an increased transformation of organic material, resulting from the catalytic action of the deleterious materials, introduced into the circulatory system from the inflamed and gangrenous textures, at the same time inflammatory fever is of a more sthenic character, and subject to less diurnal variation, and the complexion of the patient is clearer, and as a general rule the spirits and strength of the patients are better than in hospital gangrene.

Small-pox. — The fever of this disease, as well as that of measles, scarlatina, typhus and typhoid fevers, in like manner with that of hospital gangrene and surgical fever, is due to the contamination of the blood by a specific organic poison. As the abnormal phenomena of hospital gangrene are due in large measure to the absorption into the blood of poisonous animal matter, and as small-pox is clearly a disease arising from an animal poison, it is therefore important that a comparison be instituted between the chemical and pathological phenomena of the two diseases. Small-pox differs from hospital gangrene in that it is caused by a poison which has a definite course to run, produces a uniform cycle of changes, and a permanent and protective alteration in the constitution; whilst the latter disease is caused by an animal poison, it does not run a definite course, but, if unchecked, may proceed to the destruction of the part affected, and may recur again and again in the same individual or wound. As we have shown, the constitutional symptoms of hospital gangrene are caused chiefly, if not wholly, by the absorption into the blood of the gangrenous matter; as soon as the wound improves, and is entirely free of hospital grangrene, the urine becomes normal in color, and the temperature and pulse return to the normal standard.

Small-pox. The fever of small-pox due to the contamination of the blood by a specific organic poison.

The poison of hospital gangrene resembles a ferment, and is produced in the manner most favorable to the development of an albuminous poisonous matter, in a state capable of exciting similar changes in the tissues and blood; and this poison, unlike that of small-pox, proceeds to contaminate and destroy, beyond redemption, the entire solids and fluids, and possesses no self-limited properties, and no power of exciting such changes as are permanent and protective against subsequent attacks.

The poison of hospital gangrene, therefore, resembles more nearly the action of the poison of certain venomous reptiles, as of the rattlesnake (*Crotalus durissus* and *ada-*

The poison of hospital

gangrene resembles more nearly the action of the poison of certain venomous reptiles.

manteus), of the water moccasin (*Trigonocephalus piscivorus*), and copperhead (*Trigonocephalus contortrix*). This disease produces a depressed, depraved state of the system, upon which other diseases may be engrafted. I have observed the supervention of varioloid in cases of hospital gangrene and pyæmia. One of the wards of the gangrene hospital at Macon, Georgia, was devoted to the treatment of small-pox; and, through the neglect of a perfect quarantine, the latter disease became pretty generally diffused amongst the unprotected nurses and patients. In this manner, we were able to determine this fact in the natural history of hospital gangrene.

The material producing small-pox being definitely related chemically and physiologically to the organic constituents of the living body, the disease presents four well-marked stages. Outline of the symptoms of the stages of small-pox.

The material producing small-pox, being definitely related chemically and physiologically to the organic constituents of the living body, the development of the disease is traceable through well-marked stages. During the period of incubation (the duration of which varies within narrow limits, according as the poison has been introduced by the mucous or cutaneous tissues, in the former case, or natural small-pox, the period of latency varying from ten to sixteen days, and in the small-pox produced by inoculation, from seven to nine days), the specific poison absorbed gradually infects the blood, rendering it contagious in its properties, and excitant and irritant to the nervous system and circulatory apparatus. The period of incubation of the small-pox poison varies within narrow limits, whilst that of hospital gangrene depends largely upon the condition of the system and wounded surface exposed to its influence. In those whose strength has been exhausted and blood deteriorated by exposure, bad diet, and severe labor, the disease may be developed within three days after the exposure to infection, or to the causes capable of exciting this morbid action.

The infection and alteration of the blood during the period of incubation in small-pox gives rise to the secondary stage of primary fever, lasting from two to six days, till the eruption appears, when, in most cases, it remits. This stage is characterized by high fever, the temperature of the axilla rising in some cases to 106° F., severe muscular pains, especially in the small of the back, nausea, and in some cases obstinate vomiting, oppression of the brain, drowsiness, stupor, and even coma, and occasionally convulsions.

Next succeeds the exudative stage, during which the eruption appears and becomes fully developed. On the appearance of the

eruption, the fever remits, the heat abates, the pain in the muscles of the back and the affection of the head subsides, the vomiting ceases, the pulse returns to the natural standard, and the temperature falls rapidly during the first and second days of the eruption, from 106° to 100° F.

About the fourth day of the eruption, and about the eighth day of the disease, inclusive, from the first attack of the primary fever, when the eruption is fully out, and the most advanced pustules commence to maturate, the commencement of suppuration is announced by the swelling of the integument, and especially of the whole face, head, and neck. During this period of intumescence (generally lasting three days), simultaneously with the renewed hyperæmia of the skin, and introductory to the change taking place in the cavities of the pustules, the fever, which had remitted, returns, and the last stage, or that of secondary or suppurative fever, commences. In cases of ordinary intensity, this stage is marked by a rise of temperature to a considerable height (104°, 105°), by acceleration of the circulation, and by slight delirium and rigors. In cases of greater intensity, severe delirium, a harsh, dry cough, and hemorrhages from the lungs and kidneys may be added to the other symptoms. The secondary fever, and the swelling and redness of the face, having lasted from three to five days, subside, and the now fully ripe pustules burst and discharge a thin yellow matter, which, concreting into a crust, falls off on the fourteenth or fifteenth day, and the disease terminates. During these changes, the temperature sinks gradually to the normal standard. The secondary fever of small-pox is clearly related to the suppurative process, and, without doubt, has much the same origin as true, uncomplicated inflammatory fever. It is mainly due to the absorption of the serum of the pus, and of the products of the inflammatory exudations.

The urine of small-pox presents changes corresponding, to a certain extent, with the four well-marked stages of the disease. In this disease, the urinary excretion presents uniform characteristics, namely, great concentration, increase of urea and uric acid, phosphoric and sulphuric acids, and diminution and even total disappearance of the chloride of sodium.

The urine of small-pox presents changes corresponding, to a certain extent, with the four well-marked stages of the disease.

The following table contains a consolidated statement of the results of the author's labors upon the changes of the urine in small-pox, during the recent war: —

TABLE OF OBSERVATIONS UPON THE PHYSICAL AND CHEMICAL PROPERTIES AND CONSTITUTION OF THE URINE IN SMALL-POX, BY JOSEPH JONES, M. D., SURGEON P. A. C. S.

Name of Patient, History of Disease, etc.	Date.	Physical Properties and Chemical Constituents of Urine.								
		Amount of Urine collected during 24 Hours, Grains.	Specific Gravity.	Color.	Urea excreted during 24 Hours, Grains.	Uric Acid, Grains.	Free Acid, Grains.	Phosphoric Acid, Grains.	Sulphuric Acid, Grains.	Chlorides, Grains.
Varioloid. — *Light Case.* — J. J. Cobb, private, C. S. A. Age, 31. Oct. 31, 1864. Variolous eruption very slight; pustules small and few, and the patient walks about; appetite pretty good. The first symptoms made their appearance about five days ago. Pain in head, limbs, and back, with fever. Eruption first noticed Oct. 30. Nov. 1. Pustules increasing somewhat in size, but still small; patient dressed and walking about; eruption so slight that the character of the disease might escape observation; heavy deposit of urates in urine. Nov. 4. Pustules disappearing; they aborted.	Oct. 31, 1 P. M., to Nov. 1, 1 P. M.	5,865	1,029	Deep orange red	227.89	7.22	16.77	15.51	41.63	Trace
	Nov. 5	13,424	1,015.5	Orange yellow	239.93	8.00	14.22	15.57	48.74	38.80
Case of Well-marked Varioloid. — Severer than the preceding, and approaching more nearly to distinct small-pox. Pustules large, well formed, but scattering. W. B. Aiken, Company A, 30th Regiment, Georgia Vols. Age, 40. Had headache, and pain in back and limbs, Oct. 24, 1864. Two days after, on the 26th, the eruption made its appearance. Oct. 31. Pustules sparsely scattered over the face, but large and well filled. Patient up and about; appetite rather poor; complains of sore throat. Nov. 1. Pustules still in process of formation; heavy deposit of urates in urine. Nov. 4, eight and a half A. M. Pustules large and distinct, fully formed, and drying. Patient, as before, up and dressed and walking about; has taken a dose of Epsom salts.	Nov. 1	7,325.7	1,028.5	Orange red	222.33	10.85	28.30	26.98	24.73	14.14
	4	8,146.9	1,036.5	Light orange	260.53	10.80	38.01	27.79	88.52	10.32
Case of Small-pox. — Austin, negro man. Oct. 25, 1864. Eruption appearing. Oct. 28. Eruption three days out; patient has cough; pulse but little above healthy standard, 88 per minute. Tongue very slightly coated; appears to be doing well; confined to bed. Oct. 29. Progresses favorably; pulse, 88; pustules distinct, and comparatively few; urine high-colored and concentrated, with heavy deposit of urates. Oct. 31. Patient doing well; tongue only slightly coated; voice hoarse; pustules forming well; heavy deposit of urates and uric acid. Nov. 1. Pustules filled and drying; continues to improve; appetite good. Nov. 4. Continues to improve; pustules drying, large, and distinct; good appetite; urine clear.	Oct. 29	6,495	1,031	Deep orange red	434.56	6.80	25.24	22 54	19.93	Trace
	30	9,322	1,024.5	Deep orange red	407.61	12.00	32.42	32.60	23.95	4.63
	31	16,967	1,016	Deep orange red	376.52	11.66	24.68	30.70	56.24	48.97
	Nov. 1	26,999	1,015	Orange	443.58	16 90	39.14	32.51	24.11	84.94
	4	23,806	1,016	Orange	555.84	18.60	46.32	46.32	31.38	63.84

Small-pox.—Charles, negro man. Age, 33. Stout, black negro. Taken with fever and headache, Oct. 22, 1864. Eruption made its appearance three and a half days after, on the 27th of Oct., 1864. Pulse full and good, 82 per minute; eruption quite full, but not confluent; has what appears to be a vaccine scar, and says that he was vaccinated when a youth; urine deep red, and concentrated; lets fall heavy deposit of urates. Oct. 30. Eruption coming on fully in face and scattering on breast, but fuller on thighs; tongue slightly coated, and red at tip and edges; heavy yellow deposit in urine. 31st. Heavy deposit in urine. Nov. 1. Pustules filled; patient doing well; still confined to bed. Nov. 2. Continues to improve; pustules drying; appetite improving. Nov. 4. Pustules drying; patient continues to improve. Nov. 5. Continues to improve.	Oct. 29	9,568	1,024	Deep orange red	450.14	7.15	29.83	33.06	30.31	Trace
	30	9,243	1,027	Deep orange red	415.02	10.41	25.93	29.39	21.30	Trace
	31	7,927	1,029.5	Deep orange red	400.97	9.31	28.37	32.60	26.96	Trace
	Nov. 1	7,457	1,030	Deep orange red	348 05	15 30	28.36	33.28	24.94	2.13
	2	10,280	1,028	Deep orange red	422.36	12.16	29.59	37.54	29.94	24.60
	5	11,770	1,023.5	Deep orange red	355.04	9.49	28.17	29.30	26.44	33.81
Small-pox.—January, negro man. Age, 24. Light case of distinct small-pox. Had pain in head and back on the 25th of Oct., 1864. Eruption made its appearance on the 27th of Oct. Nov. 1. Patient doing well; urine deep-colored. Nov. 4. Pustules out in large numbers, fully formed, just beginning to dry upon surface; appetite good.	Nov. 1	6,444.9	1,023	Orange	240.86	6.40	28.16	27.79	15 64	1.85
	4	19,544	1,018.5	Orange	602.79	9.27	65.90	52.95	46.86	8.65
Case of Confluent Small-pox.—James Graves, 2d Regiment Georgia Reserves. Was taken with a chill, followed by high fever, Oct. 26, 1864. Has had high fever up to the present time, November 1. The eruption attracted notice first on the night of the 27th, three days ago. At the present time, Nov. 1, face covered with the eruption, and much swollen; eyes irritated and discharging matter; pustules confluent; heavy deposit in urine. Nov. 4. Confluent eruption encrusts the entire face like a filthy mask. Nov. 5. Continues to improve; pustules drying.	Nov. 2	9,718	1,022.5	Bright red	351.29	11.11	45.62	68.48	24.27	Trace
	5	4,807	1,028	Red	176.01	4.50	21.84	15.74	19.66	Trace
Confluent Small-pox.—Sawney, negro man. Age, 22. Was taken with characteristic symptoms of small-pox, Oct. 25, 1864. Nov. 2. Pustules not well filled; confluent; patient delirious. Nov. 4. Pustules filled; confluent; mind clear; urine high-colored, concentrated, with heavy deposit of uric acid and urates.	Nov. 4	12,264	1,022	Red	469.37	10.64	49.87	46.93	33.36	Trace

When it is considered that these patients partook of but little food, and were in a state of almost absolute rest, it is evident that the urea is considerably increased in the urine of small-pox, amounting in one case to over six hundred grains during the twenty-four hours. As a general rule, the increments of this constituent corresponded with the severity of the disease, being but little above the normal standard in mild cases of varioloid, and increasing to double and even treble the usual amount in cases of confluent small-pox. In like manner, the uric acid and the phosphoric and sulphuric acids were increased. The excretion of these constituents furnishes a measure of the destructive metamorphoses of the blood and muscular and nervous systems during the progress of the disease. The uric acid and urates exist in such large amounts in the concentrated and scant urine of small-pox as to form heavy deposits upon cooling. Uric acid is in like manner largely increased in hospital gangrene; and this increase, as in the case of small-pox, must be referred to the derangement of the nutrition, and oxidization of the nitrogenized elements and constituents and tissues.

Urea, uric acid, phosphoric acid, and sulphuric acid increased in the urine of small-pox.

The great concentration of the urine in small-pox may be due to several causes, as the congestion of the kidneys, the peculiar constitution of the blood, in virtue of which the water is held more tenaciously in combination with the nitrogenized elements and constituents, and the large abstraction of this constituent of the blood during the morbid changes in the integument.

The rapid diminution and complete disappearance of the chlorides during the exudative and suppurative stages of small-pox is important, as illustrating the offices of these metallic salts in the animal economy. The chlorides disappear so completely from the urine of severe cases of small-pox, that nitrate of silver gives scarcely a perceptible turbidness, when added to the urine acidulated with nitric acid. The wide diffusion of the chloride of sodium through the solid and fluid portions of the earth's surface, and its similar diffusion throughout all animal substances in definite proportions, as well as the craving of men and animals for this substance, and its established beneficial effects when used as an article of food, point to the importance of this substance in the metamorphosis of animal tissues. It is now well established that this salt is constantly associated with certain animal matters, and essentially influences their chemical and physical properties, rendering albumen, casein, and fibrin more soluble, and modifying their coagulating properties. The influence

Rapid diminution of chlorine in the urine of small-pox. Significance of this diminution.

which this salt exercises on these protein compounds, and upon the physical properties of the blood corpuscles, as well as its relations to urea and glucose, renders the view probable that it is capable of forming definite chemical compounds with certain organic bodies which are most active in the changes characteristic of inflammation.

Recent investigations upon the composition of inflammatory exudations, pus and mucus, indicate that this salt discharges an important office in the metamorphosis of the inflammatory materials of various diseases, as pneumonia and small-pox.

And it is not unreasonable to refer the absence of this salt from the urine in small-pox, not merely to the diminution of the amount ingested with the food, but to its abstraction by the exudation, and the part which it plays in the metamorphosis of the organic constituents into organized cells and fibres.

During the active stages of hospital gangrene, pus is not formed, and the exudation does not progress to the formation of cells and new tissue, as in pneumonia and small-pox; and it is worthy of note that there is comparatively small diminution of the chloride of sodium in the first named disease.

Typhoid Fever. — The fever accompanying hospital gangrene, without doubt, partook of the nature of continued fever, and has even been confounded with typhus fever; and the expression has been used by a distinguished writer with reference to the hospital gangrene of the Crimea, that it was in many cases a veritable "*child of the typhus.*" During the recent war, genuine typhus fever was almost unknown in the Confederate army, and the continued fever of the camps was in all respects typhoid or enteric fever. The continued fever of hospital gangrene, whilst possessing some points in common with this disease, differed in that it was of uncertain duration, depending upon the condition of the wound, and was not so marked in its elevation of temperature, and the destructive metamorphosis of tissue was less. The following table, drawn up from my investigations upon the continued fever of the Confederate camps and hospitals, will furnish data for comparison with the preceding observations: —

Typhoid fever. Comparison of its phenomena with those of hospital gangrene.

TABLE OF OBSERVATIONS UPON THE CHANGES OF THE PULSE, RESPIRATION, AND TEMPERATURE, AND THE CHEMICAL AND MICROSCOPICAL PECULIARITIES OF THE URINE AND CONSTITUTION OF BLOOD IN TYPHOID FEVER, BY JOSEPH JONES, M. D., SURGEON U. S. A.

Outline of Case	Pulse, Respiration, and Temperature	Physical Properties and Chemical Constituents of Urine
Kirby, Confederate soldier; three-fourths Indian. Light copper complexion; black hair, black eyes; stout, athletic man. Height, 6 feet. Weight, 160 lbs. Age, 27. July 19, 1862, was taken at night in his tent with headache and fever, preceded by no chill, and no sensations of chilliness. Patient walks about the ward and hall of the hospital, but is very weak after exertion; no treatment beyond ice-water, ad libitum. July 21, fever continues; bowels were opened by a purge; evacuations copious; sulphate of quinia freely administered, without, however, producing any effect in arresting the fever. July 22, intellect dull, lies in a partial stupor, and sometimes there is low muttering delirium; when aroused, however, answers coherently for a few moments. Bowels loose; light-colored, copious stools. July 25, no improvement; the fever appears to be declining; has taken 25 grains of quinia each day during the past three days, with no appreciable effect, except to render the patient deaf, dull, and stupid. July 30, after employing the quinia daily up to this time, its use was abandoned. July 31, lies in bed like a man whose nervous and muscular powers are completely exhausted; intellect in the same sluggish,		

lethargic state; bowels loose, and distended with flatus; short, troublesome cough; lower portions of lungs dull upon percussion. Aug. 1, continues in the same depressed state, with low muttering delirium; the characteristic eruption and symptoms of typhoid fever present. Aug. 5, marked improvement of symptoms. Aug. 6, continues to improve. This patient gradually improved.	28	14	10 P. M.	80	20	100.9	101.8	21,578	Orange	1,015	-	-	-	-	-	-
	29	15	11 A. M.	88	22	99.9	100.7	17,983	Orange	1,016.5	-	-	-	-	-	-
	30	16	11 A. M.	80	20	99.1	99.5	13,507	Orange	1,021	-	-	-	-	-	-
	31	17	11 A. M.	84	20	95.9	100.4	13,507	Orange	1,021	-	-	-	-	-	-
	31	17	10 P. M.	84	20	95.9	100.4	13,507	Orange	1,021	-	-	-	-	-	-
	32	18	11 A. M.	82	20	98.3	101.3	13,507	Orange	1,015	-	-	-	-	-	-
	35	19	11 A. M.	90	22	100.7	101.1	23,753	Orange	1,012.5	-	-	-	-	-	-
		1862														
Chaney, Confederate soldier. Age, 33. Height, 5 feet 10 inches. Weight, 150 lbs. Brown hair, brown eyes. July 12, 1862, manifested slight febrile symptoms, and complained of feeling unwell. A purgative was administered, and followed by full doses of quinia. July 13, medicine acted freely, but fever did not subside. July 15, fever increased; slight cough; pain in head. July 18, pulse 118; tongue coated; great thirst; body emits an unpleasant odor. 10 o'clock P. M., pulse 120; delirious at times. July 20, fever continues; some crepitation in right lung, which is dull upon percussion in the lower portions. July 23, talks much, and appears at times to be out of head. July 27, says that he feels better. Patient continued to improve, and convalescence was fully established on the 31st of July.	7	July 19	A. M.	118	18	106.9	107.2	19,789	Deep orange	1,021.7	786	17.43	75.9	78.2	56.3	33.6
	10	22	12 M.	104	22	105.1	105.3	19,604	Deep orange	1,016.3	567.4	11.18	80.71	58.96	54.86	3.98
	11	23	12 M.	96	22	104.3	105.1	18,180	Deep orange	1,010	501.6	-	13.6	38	35.1	1.86
	12	24	12 M.	98	28	101.1	102.2	17,558	Deep orange	1,012	594	-	50.93	64.3	58.3	3.87
	13	25	A. M.	92	28	101.8	102.2	17,558	Deep orange	1,012	594	-	50.93	64.3	58.3	3.87
	14	26	11 A. M.	82	16	102.3	102.5	19,126	Deep orange	1,012	741.1	-	50.93	28.2	26.4	2.92
	15	27	A. M.	76	16	102.3	102 5	-	Deep orange	1,012	-	-	-	-	-	-
	16	28	A. M.	76	20	110.4	101.1	19,126	Deep orange	1,012	741.1	-	-	23.2	26.4	2.92

Great and remarkable increase of the solid constituents of the urine in typhoid fever.

During the active stages of typhoid fever, whilst the temperature is elevated, the circulation accelerated, and the respiration labored, the intellect wandering, and the muscular and nervous powers prostrated, rapid and destructive chemical changes take place in the blood and in the nervous and muscular structures, as evidenced by the great and remarkable increase of the solid constituents of the urine.

Urea greatly increased.

In the first case which we have brought forward to illustrate the composition of the urine in typhoid fever, during the height of the disease, upon the tenth, eleventh, twelfth, thirteenth, and fourteenth days, the average amount of urea excreted was 886 grains, and upon the fourteenth day the urea reached the high figure of 1,145 grains. During the period that this large amount of urea was excreted, little or no food was consumed; in fact, the patient might be considered as in a state of starvation. If we place the average amount of urea excreted by men moderately well fed, engaged in the ordinary exercise of the duties of life, at 500 grains, it is evident that the amount of urea was doubled in this case during the active stages of the disease. The experiments of Dr. Hammond and others have shown, that, during starvation, not more than 200 grains of urea are excreted daily, and the quantity may even sink as low as 100 grains. In this case, therefore, the urea was five times as abundant as it would have been in an individual in health similarly starved. This increased production of urea is clearly due to the increased chemical changes excited in the nitrogenized constituents by the action of the typhoid poison. We thus have an explanation of the rapid and extensive waste of the muscular structures in typhoid fever. In nine days, during the height of the fever, this patient lost no less than 7,251 grains of urea. If we accept the formula $C_2H\,N_2O_2$ for urea, we may readily calculate the amount of nitrogen which escaped from this patient during this period, and this will furnish important data for the calculation of the approximate amount of nitrogenized materials in the blood and tissues, from the decomposition of which this element of the urine was derived: 3,383 grains of nitrogen were excreted by this patient from the fourth to the fourteenth day of the fever.

Explanation of the rapid waste of muscular tissue in typhoid fever. Relations of urea to the changes of muscular fibre.

It would certainly greatly facilitate our investigations upon the phenomena of fever, if we were able to point out with accuracy the tissues and substances which yielded the chief constituent resulting from the decomposition of the nitrogenized substances of

the body. Whilst these questions have not been definitely settled, still such intimate chemical relations exist between certain elements of muscular structure from which urea may be formed by artificial process, and the muscular structures present such vital activity, such marked and rapid metamorphosis of their nitrogenized constituents, that we are justified in referring to the muscular structures as one of the chief sources of urea. This view is sustained by many facts established by various physiologists, as the waste of muscular structures under starvation and exercise, and the increase of urea under increased muscular exertion, even during starvation, and the marked diminution of urea when the muscular structures are kept at rest. We naturally connect together the rapid waste of muscular structure and the large increase of urea, even during starvation, in typhoid fever, and are justified in inferring that the former is the source of the latter, in large measure, at least. We have elsewhere shown that the albumen of the blood diminishes in typhoid fever, whilst the colored blood corpuscles are but slightly affected.

In this fever, therefore, whatever the case may be in health, the urea is not derived from the decomposition or chemical changes of the colored blood corpuscles. The bearing of this question is important, in its connection with certain physiological problems.

Whether or not the whole mass of blood be diminished in typhoid fever, it is very evident that the albumen and fibrin are in many cases decidedly diminished. And whilst we cannot determine whether these elements were directly decomposed in the blood, or whether they first entered into the composition of the organs and structures, and especially of the muscles, and passed through a definite series of changes before being reduced to urea, we are nevertheless justified in selecting albumen and fibrin as the representatives of the nitrogenized tissues and constituents from which the urea has been derived. The fact that albumen forms the great soluble constituent of the blood, as well as its direct chemical and physical relations to the nitrogenized structures, furnish reasons for its selection as their great representative, in the attempt to determine approximately the waste of the body resulting during these nine days of fever, from the formation and excretion of 7,251 grains of urea. It would cause a needless consumption of time to dwell upon the well-established and universally admitted facts, by physiologists, that albumen occurs in all those animal substances which supply the whole body, or individual parts of it, with the materials necessary for nutrition and the renovation of effete mat-

ter; that albumen forms the principal constituent of the blood, the lymph, and chyle, and of all those serous fluids which contribute directly towards the nutrition of the organs; and that albumen requires but very slight modifications to become consolidated under different forms into various structures, and especially into the muscular structures. In like manner, it would involve a needless waste of time to attempt an explanation of the exact mode in which albumen is converted into fibrin, or attempt to decide the question whether the protein substance which can be extracted from the muscular fibrils by dilute hydrochloric acid, called, by Lehmann, syntonin, and which appears to be the true matrix of the essential element of animal motion, both in the striped and unstriped muscles, be directly derived from the albumen of the blood, or from the fibrin which had in turn been derived from albumen. The only essential fact to the accuracy of the present calculation is the very near relation of albumen, fibrin, and syntonin, and the essential element of animal motion.

It would, without doubt, render the calculation far more useful and accurate, if we were able to determine the exact relations of the syntonin to the complex contents of the muscular fibrils, to the gelatinous substance, the creatine, creatinine, inosic acid, lactic acid, and other undefined constituents of the muscular juice. Such an attempt, however, would end only in profitless speculation, for it must be confessed that the exact relations of these various constituents of muscles to syntonin and fibrin and albumen have not yet been satisfactorily determined; and whilst it is easy to represent on paper, by figures, the amount of oxygen which it would require to reduce the syntonin or the fibrin or the albumen to such states as creatine or creatinine, still these arithmetical amusements would afford no true explanation of the actual changes, which, for all that we know to the contrary, may involve a number of complex processes of arrangement and of reduction, as well as of progression, oxidation, and resolution into simple compounds.

Method of calculating the amount of flesh consumed during fever from the amount of urea excreted.

If we take the nitrogen of the urea (3,383 grains) as the basis of the calculation, then 7,251 grains of urea represent 21,825 grains of albumen, or 21,967 grains of fibrin, or 22,111 grains of unstriped muscular fibre, or 21,392 of syntonin, the chief constituent of both striped and unstriped muscular fibre. In this calculation it is assumed that the nitrogen is the stable element of nitrogenized substances, and that whatever changes and losses the carbon and hydrogen may undergo, the nitrogen remains to a great extent un-

altered. If, however, it enters into the various chemical changes, and is finally evolved to a certain extent as pure nitrogen, then the figures here representing the equivalent of urea in albumen, fibrin, unstriped muscular fibre, and syntonin, are lower than they should be. These nitrogenized bodies are here considered in their anhydrous state, and the calculation does not give us a correct representation of the absolute amount of flesh in its natural, living, moist condition, corresponding to the urea excreted by this patient during nine days of typhoid fever. Von Bibra found from 72.56 to 74.45 pounds of water in the 100 parts of human muscle. Lehmann, from a course of observations instituted by one of his pupils, affirms that water existed in upwards of 80 parts in the 100, of the muscles of the bodies of healthy persons who had committed suicide. Berzelius estimated the quantity of water in the muscles when in a fresh state at 77.5, and Schatz at 77.6 in the ox. Lehmann gives the mean results of the determinations of various observers of the water and solids of the muscles, at water, 74.0 to 80 per cent; solid constituents at 26.0 to 20 per cent. If we employ the last figures, we obtain the following results: 7,251 grains of urea represent in the living, moist condition, from 85,042 grains to 110,555 grains of unstriped muscular tissue, or from 82,661 grains to 106,960 grains of syntonin.

In nine days the urea excreted by this patient would represent from twelve to sixteen pounds avoirdupois weight of muscular structure, and a still larger proportion of albumen, as this element in the animal body is associated with a larger proportion of water. If we connect with this the loss of various constituents, nitrogenized and non-nitrogenized, and mineral, which appear in the urine as free acid, uric acid, extractive and coloring matters, free phosphoric and sulphuric acids, chloride of sodium, and the phosphates and sulphates of alkalies and alkaline earths, as well as the free evacuations of the bowels and the excretions of the lungs and skin, we have an explanation of the rapid and characteristic waste in typhoid fever. We have here a solution of the important question as to the cause of the great increase of heat in typhoid fever.

In nine days of the active stages of typhoid fever, the urea excreted represented from 12 to 16 lbs. of muscular structure.

By a comparison of these results with those relating to hospital gangrene previously rendered, it will be seen that the solid constituents of the urine are far more abundant in typhoid fever, and the temperature is higher and more uniform, the diurnal variations being far less. It results from this that the waste of tissue is less and more gradual in hospital gangrene. We conclude, therefore, that

The solid constituents are more abundant, and the temperature is more elevated in typhoid fever than in hospital gangrene.

the fever accompanying the active stages of hospital gangrene partakes more of the nature of inflammatory and hectic fever than of true typhoid or enteric fever.

Uric acid increased in both diseases.

The uric acid was increased in typhoid fever, and as in hospital gangrene, it presented none of those sudden variations in amount which characterize malarial fever. This uniform presence of uric acid in increased amount, as well as the absence of marked fluctuations in it, are valuable facts in enabling the physician to still farther distinguish typhoid from malarial fever.

Phosphoric and sulphuric acids increased, and the chlorine decreased in typhoid fever. Method of estimating the waste of the nervous and muscular structures from the amounts of phosphoric and sulphuric acids excreted in the urine.

The phosphoric and sulphuric acids are increased in typhoid fever, whilst the chlorine and consequently the chloride of sodium is diminished to a marked degree. As the amount of nitrogen excreted in the urine was made the basis of calculation for the determination of the amount of nitrogenized matter chemically altered during fever, in like manner phosphorus and sulphur may be employed in the calculation of the extent of the chemical changes of the structures and substances with which they are essentially associated. If the daily amounts of phosphoric acid excreted by healthy active men, living upon their ordinary diet, and taking their usual exercise, as determined by Breede, Neubauer, Mosler, Winter, Hammond, and others, be compared with the amount of phosphoric acid excreted during the active stages of typhoid fever, it will be evident that the latter not only equals the former, but in most cases exceeds the amount of phosphoric acid excreted in health upon full diet.

To appreciate correctly the importance of this fact, we must consider, first, the condition of absolute rest, in which the typhoid fever patients were placed; and, second, the condition of partial and in some cases almost absolute starvation in which patients suffering with this disease are necessarily placed during the active stages of the disease, when they are incapable of taking anything more than small quantities of simple fluid nourishment.

It has been clearly demonstrated by the investigations of Lehmann and others, that intellectual and bodily activity increases the amount of urea and phosphoric acid and sulphuric acid in the urine, whilst rest, on the other hand, causes a marked diminution of these constituents.

Diminution of food exerts still more marked influence upon the excretion of phosphoric acid, urea, and sulphuric acid. Mosler found that during abstinence from food, even for a short period, phos-

phoric acid, sank to half the ordinary quantity. During the ten days in which Dr. Hammond confined himself to a diet of albumen, the phosphoric acid in the urine sank from 86.17 grains the first day of the experiment to 9.15 grains on the tenth day; during a similar period in which this observer confined himself to starch, the phosphoric acid decreased in like measure progressively, but to a greater extent, and upon the tenth day of the experiment reached the low figure of 5.81 grains during twenty-four hours, and the daily average for the entire period of ten days, excreted by this stout, athletic observer, engaged in his ordinary duties, was only 18.66 grains; and, finally, during the diet of gum-arabic, this constituent of the urine decreased in four days from 24.12 grains the first day to 4.55 grains the fourth day, when the experiment was ended.

In the first case of typhoid fever, the phosphoric acid during the height of the fever, whilst the temperature of the body was 106.3° F., reached 57.5 grains during twenty-four hours.

In the second case of typhoid fever, during the height of the disease, whilst the temperature of the body was 107.2° F., the phosphoric acid reached the high figure of 75.9 grains during twenty-four hours.

As these patients were consuming but very small quantities of milk as nourishment, and as they were in a state of rest, it would be within the bounds of truth to place the amount of phosphoric acid which would have been excreted during health under similar circumstances, at 20 grains; and if we accept the experiments of Hammond as accurate, it would be correct to estimate the amount of phosphoric acid at a much lower figure, corresponding with the amount excreted by this observer upon the last day of his experiments. The amount of milk consumed by each of the patients during the twenty-four hours was not more than one pint. If the phosphoric acid in this milk be calculated by the analyses of R. Weber and Hardin of cow's milk, it will be found to be less than ten grains. In the normal state, a portion of this would be retained in the various organs and tissues. Allowing, however, that the entire phosphorus and phosphoric acid of the food appeared in the urine during the active stages of the disease, there are still remaining more than ten grains, according to this calculation, which would be twice as great as the quantity ordinarily excreted in health during starvation. It would be just, therefore, to consider 55.9 grains of phosphoric in the second case, and 87.5 grains in the first case, as clearly the results of the chem-

ical changes of various substances containing phosphorus and phosphates during twenty-four hours. This increase of the phosphoric and sulphuric acids from three to six fold in the urine of typhoid fever is clearly due to the increased chemical changes excited by the febrile poison of typhoid fever. In attempting to determine the tissues of the body which furnish the increased amounts of phosphoric and sulphuric acids, we are met with the facts, which I have established by numerous and laborious experiments, that these acids exist chiefly in an uncombined state in the urine of typhoid fever. The alkaline bases are inadequate to the saturation of the mineral acids. Now if a large proportion of the phosphoric acid and even of the sulphuric acid in the urine of typhoid fever be not combined with alkalies and alkaline earths, it is reasonable to suppose that these free acids have resulted from the oxidation of sulphur and phosphorus in the muscular and nervous structures.

The increase of the phosphoric and sulphuric acids in the urine of typhoid fever clearly due to the increased chemical changes excited by the febrile poison of typhoid fever.

The wandering intellect, the low muttering delirium, the twitching tendons, and the utter prostration of the muscular and nervous forces, characteristic of this disease, are attended by, if not directly referable to, rapid and destructive chemical changes of the elements of the muscular and nervous structures.

The nervous disturbances and debility characteristic of typhoid fever are in a measure, if not entirely, due to these rapid changes in the phosphorescent materials of the nervous structures, and especially of the central ganglionic cells.

And in conclusion, the careful comparison of the changes of the blood in hospital gangrene with those of typhoid fever, taken in connection with the preceding analysis and comparison of the physical and chemical phenomena of the two diseases, leads to the conclusion that the poisons inducing the two diseases are different in their mode of origin and action, and that the fever of hospital gangrene is most nearly allied to inflammatory and hectic fever.

Poisons inducing typhoid fever and hospital gangrene different in their natures.

CHAPTER FOURTH.

Progress of Hospital Gangrene to Recovery. — Cases illustrating the Slow Convalescence which follows in Cases in which the Constitution has been extensively involved. — Disability resulting from Hospital Gangrene. — Number of Men disabled by Hospital Gangrene in the Army of Tennessee during the Months of July and August, 1864. — Causes of Death in Hospital Gangrene, and Results of Post-mortem Examinations. — 1. Progressive Failure of the Powers under the Action of the Depressing and Irritating Effects of a Large and constantly Increasing Wound, and of the Derangement in the Constitution of the Blood and of the Nutrition, induced by the Absorption of the Gangrenous Matter and its Products. — 2. Hemorrhage from the Blood-vessels exposed and eroded by the Gangrene. — 3. Entrance of Air into Veins eroded and opened by the Ravages of Hospital Gangrene. — 4. Opening of Large Joints by the Gangrene. — 5. Formation of Large Bed-sores during the Progress of the Disease, and the Appearance of Gangrene in them. — 6. Diarrhœa resulting from the Irritant Action of the Poison of Hospital Gangrene upon the Intestinal Mucous Membrane. — 7. Extensive and Rapid Disorganization of the Tissues around the Original Wound, beneath the Sound Skin, accompanied by Absorption of the Gangrenous Matters, great Nervous and Muscular Prostration, and Obstinate Diarrhœa. — 8. Mortification of Internal Organs, induced by Gangrenous Matter absorbed by the Local Disease. — 9. The Invasion of Organs essential to Life, by the Direct Destruction of Intervening Structures. — 10. Pyæmia; Investigations upon the Changes of the Temperature, Pulse, Respiration, and Urine in Pyæmia, illustrated by Cases. — 11. Phlebitis. — 12. Various Sequelæ.

Progress of hospital gangrene to recovery; local and constitutional changes.

THE complete separation of the ragged, spongy, gray sloughs, and the appearance of healthy granulations and pus in the wound, and the arrest of the further progress of the gangrene, are certainly attended if not preceded by corresponding improvement in the constitutional symptoms. The pulse becomes fuller and slower, the diurnal variations of temperature less, the normal relations between the temperature of the extremities and of the central organs are reëstablished, the capillary circulation in the extremities becomes more active, the appetite improves, the complexion loses its leaden, dusky, unhealthy hue, the eye expresses hope and life, and the distressed countenance becomes cheerful. Corresponding changes are observed in the urinary excretion; as the wound improves, the urine progressively loses its high color and the febrile characters, and approaches by gradual degrees the standard of health. I have as yet observed in this disease no crisis or sudden change in the urine during the period of convalescence. In this respect all the symptoms correspond, in that they all gradually and progressively improve without any marked or sudden changes as in certain diseases, as in malarial fever.

The favorable changes which I have just indicated, will frequently take place even when a most extensive surface is exposed and raw, as a large portion of the muscles of the back, or of the buttock, or of the thigh, six or eight inches in diameter.

Constitutional disturbances not due exclusively to the local irritation of the nerves exposed by the gangrene.

The fact that all the constitutional symptoms may improve, even before the diminution of the size of the wound, and whilst a large raw surface of muscles, nerves, blood-vessels, and bones remains exposed, demonstrates conclusively that the constitutional disturbances are not due exclusively or even in great measure to the local irritation of the nerves exposed to the gangrene.

No uniform periods or stages in the progress of hospital gangrene. Its progress dependent largely upon the state of the system, diet, habits, and hygiene.

I have observed no uniform periods in the progress of the disease, to either a favorable or fatal termination.

As far as my observation extends, the duration of hospital gangrene depends upon the condition of the system and constitutional powers at the time of the infection; the extent to which the constitution is involved by the absorption of the gangrenous matters; the position, relations, and functions of the diseased parts; the rapidity and extent to which the disease progresses before being arrested by the powers and processes of nature, or by treatment; the nature of the local and constitutional treatment; and above all, upon the hygienic condition of the hospital in which the patients are treated.

Bad diet, previous exposure, together with the atmosphere of crowded, filthy camps, beleaguered cities, and filthy, crowded prisons, induce a state of the system which favors the origin and rapid spread of hospital gangrene. Such derangement of the blood and tissues and of the physical and vital forces as we find in scurvy, appear to be eminently adapted to the rapid spread of hospital gangrene. The effects of bad diet, exposure to cold and wet with imperfect clothing, and of the constant inhalation of deleterious gases arising from animal and vegetable decomposing matter, may gradually induce such a change in the composition of the living tissues that they are prone to disintegration; and when any poisonous agent capable of exciting rapid change, as that which produces hospital gangrene, is introduced, the physical and chemical constitution of the living tissues is such, and the physical and vital powers are so reduced, that the disintegration excited is not only rapid, but wide-spread. We might call this an unstable condition of the chemical elements and physical and vital forces of the living system, and with some analogy compare it to that of certain unstable compounds, as the iodide of nitrogen and chloride of

nitrogen, which are rapidly altered even by mechanical motion. It is manifest that when such a state of the system has been induced, the spread of gangrene will be far more rapid and extensive, and the convalescence will be more tedious, than in healthy constitutions. And even under the best local treatment, the recovery is necessarily tedious in constitutions broken down by the agencies just specified, and by habits of intemperance and vice.

Even when the constitution is vigorous and healthy before the infection, the absorption of the gangrenous matter and its products may induce a state of general derangement and depression, similar to that just alluded to as resulting from the causes which may be considered as extraneous and accidental. When the system has been once thoroughly poisoned by the matter of hospital gangrene, the recovery will be tedious, if not exceedingly doubtful, under the best local and constitutional treatment.

Effects of temperament upon the progress of the disease.

The natural temperament appears to exert an important effect upon the progress of hospital gangrene. All things being equal, the disease will be most readily managed, and convalescence will be most rapid in the nervo-sanguine temperament. Men with black hair and eyes, and dark, sallow complexions, of the bilious, nervo-bilious, and bilio-lymphatic temperaments, appear to suffer most in the active stages, and to have the most tedious convalescence. One or all of these causes may tend to aggravate the disease and prolong its course. Any system of treatment which neglects the previous condition of the system, or that induced by the absorption of the poison and its products, should be condemned as radically defective. Thus, in hospital gangrene engrafted upon a scorbutic system, what philosophy would it be to treat the disease entirely by local remedies, without any attention to the derangements of the blood and of several of the important organs, and of the general nutrition of the body?

The position, relations, and functions of the diseased parts have much to do with the character and duration of hospital gangrene.

That the position, relations, and functions of the diseased parts have much to do with the character and duration of hospital gangrene, would seem to be almost self-evident. The disease is especially dangerous when located upon or in the vicinity of a large joint, or along the track of important blood-vessels, as upon the neck over the track of the jugular veins and carotid artery, or in the thigh over the femoral vein and artery, or in the neighborhood of important organs, as the testicles and lungs. I have never seen

a case of recovery from this disease, after the opening of the hip or knee joints; and in fact, in all cases where the elbow joint was opened in which amputation was not performed, the result was fatal. The exposure and consequent death of bones denuded of flesh and periosteum by hospital gangrene, greatly prolong convalescence. A portion of dead bone is one of the most common causes of prolonged and tedious and exhausting suppuration from wounds, even after the removal of all gangrene and the establishment of healthy florid granulations. The florid granulations, which at first often cover the end of a dead bone and sprout from its marrow, will most generally wither, and the dead portion of bone will exfoliate, and eventually be cast off. The system may, after a prolonged struggle, finally sink under the irritation and extensive suppuration caused by a portion of dead bone, after the system has successfully resisted the most extensive and dangerous destruction of tissues by the gangrene. We had a good illustration of this in the case of Captain Cox.[1] In such cases, nature perishes in the attempt to throw off the dead bone; or during the depressed and irritated state induced by the action of the poison and by the inflammatory processes and constitutional disturbances which it has excited, the stomach and bowels may give way, and the patient may fall a victim to gastritis or diarrhœa.

The following case will serve to illustrate a large class of these ill-conditioned wounds and stumps, resulting from the action of hospital gangrene, in which the convalescence is most tedious and doubtful: —

Case XXXIV. Illustrating the tedious and doubtful convalescence of many cases of hospital gangrene.

Case XXXIV. Thomas O. Turner, private, Company C, 7th Florida Regiment, Army of Tennessee. Native of Camden County, Georgia. Has resided in Florida since he was eleven years of age. Has been in Confederate service since the 24th of March, 1861. Was sick with typhoid pneumonia at Loudon, Tennessee, in the spring of 1862. This is the only attack of sickness with which he has suffered up to the time of the reception of the present wound. Age, twenty-nine. Height, five feet eleven and one half inches. Weight in health, one hundred and sixty pounds. Black hair, beard, and eyes. Dark, sallow complexion. Habits virtuous and temperate. Was wounded at Jacksonboro', 31st of August, 1864. Minie-ball shattered the elbow. Arm amputated near the middle, on the field of battle. Was sent immediately to Griffin, Georgia, and remained there nearly one month. I have been unable to ascertain certainly whether this patient suffered with gangrene during this

[1] Chapter Third, Case X.

month; it appears, however, that he did not, as he affirms that his wound appeared to be progressing pretty well until he was transferred to the Stout Hospital, in Macon, Georgia. After entering this hospital, his wound was pronounced to be gangrenous, and he was sent to the Empire Hospital, at Vineville, Georgia, on the 23d of September.

October 25. — Dark, sallow, anæmic, unhealthy complexion. The stump for near one month has been in a miserable condition; inflamed, swollen, and exceedingly painful, with ragged, everted edges, and a black projecting bone. During the past week the wound has improved considerably, and the swelling and marks of inflammation in the stump have been greatly reduced under the careful attention of Assistant-Surgeon Perry. The stump presents the appearance represented in Plate No. XXI.[1]

Much of the dark-looking portions are due to the action of nitrate of silver. With this pale, unhealthy, flabby, ragged condition of the wound, with the dead black bone projecting, exists the sallow, dusky hue, and great exhaustion and derangement of digestion. Patient does not weigh more than ninety pounds; a mere skeleton, very nervous and irritable; cries like a child whenever the wound is touched, although in health a brave and gallant soldier, who has fought many battles. Bowels running off. Appetite poor. Tongue clean, and only moderately red. Pulse quick and jerking, and feeble.

Twenty days after this observation, this patient lay in much the same state, with little or no change in the wound or in his general symptoms, and upon this, my last observation upon the case, I considered his recovery doubtful in the extreme.

The following case will illustrate the slow convalescence which follows in cases in which the constitution has been extensively involved: —

Case XXXV. Illustrating the slow convalescence which follows when the constitution has been extensively involved.

Case XXXV. A. M. McGowan, Lieutenant, Company K, 3d Mississippi Battalion, Lowrey's Brigade, Cleburn's Division, Army of Tennessee. Light hair; fair complexion; blue eyes. Age, twenty-nine. Wounded at Atlanta, Georgia, October 31, 1864. Minie-ball struck the outer portion of the lower third of the left thigh, about five inches above the knee joint, and passed through the muscles without injuring the femur. Remained in the brigade hospital until next day; then sent to Griffin, where he remained one night, and was then forwarded to Newsom Hospital, at Thomaston, Georgia, and after remaining here until October 2d, was transferred to Ocmulgee Hospital, Macon, and finally was sent to the Empire Hospital, October 5. Gangrene made its appearance in this wound, September 10.

October 5. — The patient has just entered the Empire Hospital, and

[1] Omitted.

is in a most deplorable condition. Pale, anæmic, dusky complexion, with swollen, ghastly features, and eyes with a dead, leaden stare. Pulse rapid and feeble. Every muscle and tendon of the entire body appears to be in a state of nervous agitation, trembling, and twitching. The gangrene has denuded the muscles upon the outer portion of the thigh to a great extent, and the wound is seven inches in the longest diameter, and about twenty-three inches in circumference. A portion of the wound presents some granulations, and secretes pus in other parts; especially along the inferior border there is some of the characteristic gray and greenish slough of hospital gangrene.

Stimulants were freely administered, and they appeared to exert a most marked effect in quieting the excessive twitching of the muscles and trembling of all the extremities.

October 6. — Six o'clock A. M. Pulse, 96. Respiration, 22. Temperature of hand, 35.2° C. (95.4° F.). Temperature of axilla, 38° C. (100.4° F.). Tongue red and dry. Bowels loose. Skin cool.

The free use of alcoholic stimulants has been attended with most beneficial results. There has been a most marked diminution of the nervous excitement and depression.

Eight o'clock P. M. Pulse, 110. Respiration, 28. Tongue red and dry. Bowels not so loose. Temperature of hand, 35° C. (95° F.). Temperature of axilla, 39.6° (102.2° F.).

October 7. — Eight o'clock A. M. No improvement of wound. Pulse, 116. Respiration, 22. Temperature of hand, 34° C. (93.2° F.). Temperature of axilla, 38° C. (100.4° F.). Bowels more regular. (Tincture muriate of iron, gtts. xx., sulphate of quinia, grains v., three times a day. Whiskey, f℥ii., three times a day. Chicken soup; bread and toast.

Eight o'clock P. M. Pulse, 118. Respiration, 24. Temperature of hand, 38° C. (100.4° F.). Temperature of axilla, 40° C. (104° F.). Tongue red and dry. Skin warm. Bowels regular.

October 8. — Nine o'clock A. M. Pulse, 110. Respiration, 16. Tongue moist. Bowels regular. State of wound and general symptoms continue much the same. Temperature of hand, 37.4° C. (99.3° F.). Temperature of axilla, 38.6° C. (100.4° F.).

Eight o'clock P. M. Pulse, 126. Respiration, 22. Tongue dry. Bowels regular. Temperature of hand, 36.4° C. (97.5° F.). Temperature of axilla, 37.4° C. (99.3° F.).

October 9. — Eight o'clock A. M. Pulse, 122. Respiration, 18. Tongue moist. Bowels regular. General symptoms and condition of wound much the same. Temperature of hand, 34° C. (93.2° F.). Temperature of axilla, 36.4° C. (97.6° F.). Treatment same.

October 10. — Nine o'clock A. M. Pulse, 124. Respiration, 16. Tongue dry. Bowels regular. Slight improvement of wound. Patient still nervous, restless, and feeble, with sallow, distressed countenance. Temperature of hand, 32° C. (89.6° F.). Temperature of axilla, 37.4° C. (99.4° F.).

Eight o'clock P. M. Pulse, 104. Respiration, 21. Tongue moist. Bowels regular. Temperature of hand, 36.4° C. (97.6 F.). Temperature of axilla, 38° C. (100.4° F.).

October 11. — Eight o'clock A. M. Pulse, 126. Respiration, 18. Tongue moist. Bowels regular. No material change in condition. Much of the rise in the pulse in the mornings is due to the application of nitric acid, and the dressing of the wound. Temperature of hand, 32.1° C. (89.8° F.). Temperature of axilla, 36.25° C. (97.2° F.).

Eight o'clock P. M. Pulse, 112. Respiration, 18. Temperature of hand, 37° C. (98.6° F.). Temperature of axilla, 38.4° C. (101.2° F.).

I was assisted in the determination of the temperature, pulse, and respiration in this case by Assistant-Surgeon Calhoun, in charge of Ward No. 3.

October 18. — Up to this time there has been but little change for the better in this patient. The treatment, together with the local application of nitric acid, has been persevered in. There is still some gangrene in the wound. Patient depressed, nervous, and emaciated; but the excessive nervous disturbance and trembling of the hands and limbs has in a great measure disappeared. Pulse 128, and feeble. Tongue bright red, and furred slightly in strips on either side of a central clean strip. Has no appetite; eats very little, and oftentimes refuses food altogether.

Examination of Urine. — Amount of urine collected during twenty-four hours, 400 CC. = grains 6,419.70. The bottle was accidentally overturned, and a portion was lost. Specific gravity, 1,019. Deep red color. Strong acid reaction. Clear when first passed. After seventy-two hours, heavy deposit of urates, of a pinkish-yellow color. The purpurine formed a beautiful layer upon the top of the yellow deposit. The deposit consisted almost entirely of granular amorphous urates, with very few defined crystals of uric acid. The chief constituent of the deposit appeared to be urate of ammonia.

ANALYSIS OF URINE, NO. 33.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours (only a portion of entire amount)	6,419.70	
Urea	203.28	31.66
Uric acid	4.96	0.77
Free acid	13.86	2.15
Phosphoric acid	11.08	1.72
Equivalent of phosphorus in phosphoric acid	4.86	0.75
Sulphuric acid	11.52	1.76
Equivalent of sulphur in sulphuric acid	4.60	0.73
Chloride of sodium	18.48	2.87
Equivalent of chlorine in chloride of sodium	11.19	1.74

October 19.—Appears to be a little more comfortable. Appetite still very poor. Had three or four loose stools during the night. Condition of the wound and general symptoms much the same.

Examination of Urine.—Amount of urine collected during the past twenty-four hours, 700 CC. = grains 11,240.40. Not the entire amount, as a small portion was lost during the action on the bowels. Specific gravity, 1,020. Strong acid reaction. The acid reaction was retained for several days, apparently with little diminution. This patient takes so little food that it would be correct to consider this the urine of starvation. Urine clear when first passed, but after standing over night (cold night), there was a slight light deposit of granular amorphous urates.

ANALYSIS OF URINE, NO. 34.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	11,240.40	
Urea	324.55	28.96
Uric acid	9.80	0.87
Free acid	29.64	2.65
Phosphoric acid	41.05	3.65
Equivalent of phosphorus in phosphoric acid	18.06	1.69
Sulphuric acid	20.64	1.83
Equivalent of sulphur in sulphuric acid	8.25	0.73
Chloride of sodium	32.34	2.87
Equivalent of chlorine in chloride of sodium	19.59	1.74

November 5.—Up to the present time there has been scarcely any perceptible improvement, with the exception of a decrease of the nervous excitement and irritation, and a slight improvement in the wound, which now presents an extensive surface of clear, raw muscles, with little or no gangrene. The wound is now twelve inches in the longest diameter, and about eight inches in the transverse or shortest diameter. There is still a little gangrene in the centre of the wound, burrowing amongst the muscles. Bowels running off. Tongue red. Pale, anæmic, sallow complexion. The complexion is clearer, however, and the pulse is fuller and stronger, and the expression of the countenance a little more cheerful.

November 10.—Continues in the same condition.

My observations upon this case did not extend beyond this date; but it will be seen that during a period of sixty days there had been but little change in the condition of either the wound or the constitutional symptoms.

The nature of the local and constitutional treatment has much to do with the progress and extent and duration of hospital gangrene; for if the disease be due to the action of

The nature of constitutional and

a certain kind of animal matter, and if it be possible to destroy that matter by chemical agents, and at the same time to arouse by the same means the surrounding tissues into healthy inflammation, it is evident that the physician possesses the means of cutting short the disease. After the removal and arrest of the local disease, the period of convalescence will depend upon various circumstances, as the extent to which the general system has been involved, the extent of the local injury, the condition of the wound, and the surrounding hygienic condition.

local treatment has much to do with the progress and duration of hospital gangrene.

But above all, the duration of hospital gangrene will depend upon the hygienic condition of the hospital, and the sanitary regulations.

Duration of the disease mainly dependent upon the hygienic condition and sanitary regulations.

If the hospital be crowded with wounded and gangrene cases, and if it be poorly ventilated, and if but little attention be paid to the cleanliness of the bedding and utensils, patients will be liable to constant returns of the disease, introduced through one or all of the avenues of infection existing in filthy, badly regulated hospitals. In such cases, patients may be cured of the gangrene several times, and finally die from a recurrence of the disease. I have seen nurses dress healthy, granulating wounds with the same filthy hands and instruments which but a moment before had been busy in cleansing and picking the most offensive gangrenous wounds. The tendency of this disease is to a low, depressed state of the nervous system and of the general and capillary circulations, and hence bed-sores are exceedingly common in this disease, when the patients are not properly attended to. There is no doubt but that, in the hands of inattentive and slovenly surgeons, this is often a cause of most tardy convalescence, and even of death itself, in hospital gangrene. The patients should be moved out of the wards into the open air whenever possible, and the most scrupulous attention should be paid to the condition of the bedding and to the change of position. The patient should be propped up in bed, if possible, for a portion of the day, at least. I have, in many cases which suffered intensely and finally died, witnessed a most lamentable indifference and inattention on the part of nurses and medical attendants to the personal comfort of the patients, and especially in the matter of shifting the position frequently, and in stimulating the parts pressed upon with various applications, as tincture of iodine, brandy and salt, and tincture of camphor, in order that the most troublesome of all complications in hospital gangrene might be avoided.

As far as my observation extends, bowel affections, and especially obstinate diarrhœa, are much more liable to occur in dirty, foul hospitals than in those properly regulated. This serious complication of hospital gangrene appears in many cases to be the immediate cause of death, by the consequent exhaustion. We will consider in the next place the effects of hospital gangrene in producing permanent disability.

DISABILITY RESULTING FROM HOSPITAL GANGRENE.

Disability resulting from hospital gangrene.

The extensive destruction of tissue caused by this disease will in many cases involve the permanent injury of the affected limbs. The character and extent of the disability will depend upon the situation of the gangrene, as well as upon the extent of its ravages. When the disease invades tissues in the region of large blood-vessels and nerves, impaired circulation, nutrition, and even complete paralysis of the parts below the seat of injury may result. Withered, discolored, cold, contracted, and paralyzed arms and legs are sometimes seen even at this early period of the war, as the results of the local injuries inflicted by hospital gangrene. Even when the important nerves and blood-vessels are not injured, the denuded muscles which have lost their natural fibrous coverings, and even in many cases their natural tendinous attachments, during the process of healing by granulation, form numerous new attachments, and the symmetry and precision of the muscular movements are deranged. When entire muscles, or only portions of one or more muscles, are destroyed, more or less contraction, according to the position and action of the muscles, will take place. In most cases, the extent of the disability is in no manner related to the size or depth of the primary wound. A small scratch of the surface may be attended with as great destruction of muscular tissue as the deepest wound.

The extent and nature of the contraction, whether forwards or backwards or lateral, will manifestly depend upon the relations and actions of the muscles injured or destroyed.

The following case is selected from a large number, to illustrate the effects of hospital gangrene in impairing the value and efficiency of the injured limb: —

Case XXXVI. Illustrating the disability caused by hospital gangrene.

Case XXXVI. M. D. Davis, Co. F, 23d Regiment, Alabama Volunteers, Pettus's Brigade, Army of Tennessee. Age, twenty. Height, five feet seven inches. Weight in health, one hundred and forty-five pounds. Native of Lowndes County, Alabama. Residence about fourteen miles below Montgomery,

Alabama, in a fertile, malarious region. Previous to entering the service, has had repeated chills. Has been in Confederate service three years. During this period, has enjoyed good health, and has suffered only with slight diarrhœa, which yielded readily to treatment. Patient says that, as far as his knowledge extends, he has never had typhoid fever. The wound from which he is now suffering is the first that he has received in Confederate service. Wounded on the 22d of June, 1864, on the Powder Springs road, near Marietta, Georgia. A shell grazed the external surface of the middle of the right thigh, and carried off a portion of the skin about two inches in diameter. The muscles did not appear to be specially injured, and the surgeon in the field considered the wound as comparatively slight. Was carried to Stevenson's Division Hospital, where he remained two days and nights. The patient affirms that, during this term, his wound received but little attention, and maggots were bred in considerable numbers in the wounded parts. Was sent from Marietta to the Fair Ground Hospital, No. 2 (Surgeon Crawford), in Atlanta. Remained in Atlanta two days and nights, and was then transferred to the Ocmulgee Hospital, in Macon. A few days after entering this hospital, gangrene appeared in the wound. On the 13th of August, was transferred to the Empire Hospital, Vineville, devoted to the treatment of hospital gangrene. At the time of his entrance, the gangrene was spreading, and the constitutional symptoms were strongly marked: sallow, unhealthy complexion, feeble, rapid pulse, great nervous excitability, with loose bowels.

The free application of nitric acid (patient under the influence of chloroform), accompanied with constitutional treatment of tincture muriate of iron and quinine, together with stimulants and nutritious diet, arrested the further progress of the gangrene. After his entrance into the Empire Hospital, before the arrest of the gangrene, the patient suffered with several chills, followed by fever. Erysipelas also appeared, and complicated the gangrene.

October 2. — Patient pale, anæmic, and greatly reduced in flesh and strength. His appetite, however, is excellent, and bowels regular, spirits good, and the constitutional symptoms relieved. The wound presents a bright red, healthy color, and is covered with florid granulations, which bleed upon slight pressure. No gangrene is to be seen in any part of the wound. The denuded surface covers the greater portion of the right thigh. The granulations have filled up in a great measure the deep interstices of the thigh, which had been dissected out by the gangrene. The raw surface is very sensitive, and the patient cries like a child whenever it is dressed or washed, or even gently touched. The slightest touch appears to occasion great pain, or else the system of the patient has been so much reduced that he is unable to bear the slightest touch without crying.

The following sketch,[1] which I have drawn of the natural size,

[1] Plate No. XXII. (Omitted.)

represents the appearance of the surface, and also the contraction of the leg and the wasted condition of the patient. The discoloration of the skin of the lower portion of the thigh and upper portion of the leg, is due to the effects of the tincture of iodine, which had been applied to arrest the progress of the erysipelas.

The right leg is firmly contracted, and the patient is unable to extend the limb more than a few inches.

October 18. — Continues to improve; appetite excellent; eats large quantities of nutritious and strong food. The spirits of this young soldier have always been cheerful and good. From the constant pressure of the head on the pillow, the scalp is now ulcerated.

Examination of Urine. — Amount of urine passed during the last twenty-two hours, up to October 18, ten o'clock A. M., 1,800 CC. = grains 28,752.80. Specific gravity, 1,016. Light orange yellow color, and turbid, from a light yellow deposit. The deposit which appeared in the urine at the end of its collection had increased considerably at the end of forty-five hours, and was almost perfectly white. Under the microscope, this deposit was found to consist of numerous octahedral and dumb-bell crystals of oxalate of lime, amorphous granular urates, and large prismatic crystals of triple phosphate, and other large tabulated, thin, transparent crystals, resembling the purer forms of urea and nitrate of urea. Urine alkaline at the time of this observation.

ANALYSIS OF URINE, NO. 85.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	28,752.80	
Urea	693.00	24.102
Uric acid	9.36	0.32
Free acid	19.40	0.709
Phosphoric acid	11.08	0.38
Equivalent of phosphorus in phosphoric acid	4.87	1.69
Sulphuric acid	34.23	1.19
Equivalent of sulphur in sulphuric acid	13.69	0.51
Chloride of sodium	110.88	3.89
Equivalent of chlorine in chloride of sodium	67.19	2.33

It is of some interest that the chloride of sodium exists in considerable amount, notwithstanding the existence of a large suppurating wound. The salt disappears from the urine in all severe diseases, not only on account of the loss of appetite, and consequent absence of salt from the food, but also because, in the febrile state of various diseases, this salt is retained in the blood and tissues. The retention of this and other salts in the blood during fever may account in a measure for the accompanying thirst. In variola (small-pox), chloride of sodium disap-

pears almost entirely during the active stages of the disease, even in patients who are walking about and eating their accustomed food.

October 19. — Continues to improve. Appetite good. The patient ate heartily of beefsteak, hash, corn-bread, loaf-bread, and drank two cups of coffee with great relish, whilst I was observing him in the ward. The ulcer on the back of his head, caused by pressure, presents a healthy appearance.

Examination of Urine. — Amount of urine passed during eighteen hours (October 18, 12 M., to October 19, 6 A. M.), 1,850 CC. = grains 39,090.50. Specific gravity, 1,016. Yellow color, with a tinge of orange. Carefully tested for grape sugar. No trace of this substance. No deposit observed in the urine twenty-four hours after its collection. In forty-eight hours, a light, cloudy deposit floated through the mass of the urine, and became gradually more dense and defined towards the bottom of the glass vessel. This deposit consisted of large, well-defined octahedral crystals of oxalate of lime. Reaction of urine, alkaline. The presence of oxalate of lime in this and in other cases of convalescence from hospital gangrene appeared to be connected with the depressed state of the nervous system, and with slightly impaired digestion, and the consumption of much food, without exercise.

ANALYSIS OF URINE, NO. 36

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during eighteen hours	39,090.50	
Urea	512.82	13.119
Uric acid	4.81	0.14
Free acid	28.49	0.72
Phosphoric acid	11.39	0.29
Phosphorus in phosphoric acid	5.00	0.15
Sulphuric acid	33.47	0.85
Sulphur in sulphuric acid	13.38	0.34
Chloride of sodium	102.56	2.62
Equivalent of chlorine in chloride of sodium	62.15	0.158

October 30. — The patient sat up outside of the hospital tent this day for the first time since his entrance into this hospital. Appetite and spirits excellent. Wound continues to fill up by granulations, and to contract in size. Sore on the back of his head healing rapidly. Some ten days ago, an eruption of pustules or small boils appeared on various parts of his body. This is now drying and rapidly disappearing.

November 5. — Walks about the streets of the hospital on crutches. Has gained considerable flesh. Spirits excellent. Wound rapidly closing. The sore on the back of the head has healed. The muscles of the thigh have not regained any of their lost motion, and the injury appears

to be permanent. At least, so great is the contraction of the muscles that the services of the soldier for active duty in the field appear to be lost to his country.

To prevent permanent contraction of the muscles and disability following hospital gangrene, requires great resolution and attention on the part of both patient and surgeon.

In the treatment of such cases, it requires great resolution and attention on the part of the patient as well as the physician to overcome the contraction of the muscles. As far as my observation extends, many valuable soldiers are lost to the service from inattention on the part of nurses and medical attendants to the posture of the body, and of the affected limb, during the progress of hospital gangrene. Whilst endeavoring to place the diseased limb in the most favorable position for a perfect cure, without unnecessary deformity and contraction, it should also be remembered that there is a marked tendency to the formation of the most distressing and dangerous bed-sores, in all parts subjected to long continued pressure on account of the depression of the general and capillary circulation, and of the nervous and muscular forces, and the derangement of nutrition induced by the absorption and action of the poison and its organic products. The physician has also to regard at the same time, with the most scrupulous care, the proper drainage of the wound.

Numbers of soldiers lost to the Confederate service on account of disability following hospital gangrene.

I have instituted inquiries at various times to determine, if possible, the number of soldiers lost to the Confederate service on account of disability following hospital gangrene, but have thus far been unable to form even an approximate estimate, on account of the following difficulties: —

It is evident that the field reports furnish no materials for such an inquiry, as the patients do not remain long enough in the regimental, brigade, and division hospitals, to determine the results of any injury; and after the patient is transferred to the general hospital, his subsequent history is in most cases lost to the field surgeon.

In the general hospitals the cases are constantly transferred from one hospital to another, and in the present system of registration, his disease and injury, with even the date and character of his wound, appears anew upon the reports of every hospital which he enters; so that the cases recorded in the general hospitals connected with the Confederate armies greatly outnumber those transferred from the field.

Again, hospital gangrene, under the title "Phagedæna Gan-

grænosa," has only recently been introduced into the list of diseases recorded in the Confederate reports of the sick and wounded. Thus the first reports from the general hospitals attached to the Army of Tennessee in which phagedæna gangrænosa appeared, was for the month of July, 1864.

I have condensed the table on the following page from the monthly reports of the sick and wounded of the general hospitals of the Army of Tennessee during the months of July and August, 1864.

During the month of July, 1864, 21 cases of hospital gangrene were admitted into the general hospitals attached to the Army of Tennessee, and amongst this number only 1 death is recorded, whilst 147 cases originated within the hospitals; 41 cases are entered as "gangræna humida;" these cases were without doubt in almost every case hospital gangrene. The total number of cases of phagedæna arising in the hospitals during the month of July would amount to 188, with 7 deaths.

During the month of August, 45 cases of gangræna humida and 4 deaths, and 230 cases of phagedæna gangrænosa and 9 deaths (total, 275 cases hospital gangrene, 13 deaths), were admitted; whilst 79 cases gangræna humida and 2 deaths, 256 cases phagedæna gangrænosa and 3 deaths, originated within the hospitals (total, 335 cases and 5 deaths hospital gangrene); thus giving a grand total of cases of hospital gangrene treated during the month of August of 610, with 18 deaths.

During the months of July and August, 819 cases, or if the 5 cases of gangræna humida admitted during the month of July be added, 824 cases of hospital gangrene were treated in the general hospitals attached to the Army of Tennessee, 26 of which proved fatal.

If we assume that one half of these cases were permanently disabled by this disease, then four hundred men were lost to the Army of Tennessee by this supervening disease, the origin of which was dependent in great measure upon the hygienic condition of the hospitals. As far as my experience extends, from a personal inspection of the sick and wounded of many of the general hospitals of the Army of Tennessee, I feel assured that this estimate is below the truth; for many more cases of hospital gangrene occurred than were entered upon the sick reports. These cases were entered simply as gunshot wounds; and even when the disease supervened, the fact of its supervention was in many cases, and

TABLE OF SICK AND WOUNDED IN HOSPITALS OF THE ARMY OF TENNESSEE, DURING THE MONTHS OF JULY AND AUGUST, 1864.

Diseases.	July, 1864.				August, 1864.				Total.	
	Original admission.		Re-ed. duri'g month.		Original admission.		Re-ed. duri'g month.			
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Gangræna sicca	2	–	7	–	11	–	4	–	24	–
Gangræna humida	5	–	41	5	45	4	79	2	170	11
Phagedæna gangrænosa	21	1	147	2	230	9	256	3	654	15
Pyæmia	–	2	25	23	8	7	72	70	105	102
Erysipelas idiopathic	56	–	4	–	37	–	5	–	102	–
Erysipelas traumatic	21	1	22	–	8	–	19	–	70	1
Contusio	394	2	1	–	184	2	3	–	582	4
Vulnus incisum	22	–	–	–	18	–	–	–	40	–
Vulnus laceratum	22	–	–	–	20	–	–	–	42	–
Vulnus punctum	3	1	–	–	4	–	–	–	7	1
Vulnus sclopeticum	9,269	416	5	–	7,961	409	25	2	17,260	827
Luxatio simplex	11	–	–	–	9	–	–	–	20	–
Luxatio composita	3	–	–	–	2	–	–	–	5	–
Fractura simplex	20	–	–	–	17	–	1	1	38	1
Fractura composita	19	2	–	–	56	–	–	–	75	2
Sub-luxatio	12	–	–	–	16	–	–	–	28	–
Concussio cerebri	7	–	–	–	10	–	–	–	17	–
Total all other diseases	–	–	–	–	–	–	–	–	–	–
Total all diseases treated in hospitals, Army of Tennessee	23,736	708	648	99	21,248	467	700	131	46,332	1,585

we might almost say in the majority of cases in certain hospitals, not recorded at all.

The truth of this proposition I have demonstrated by an actual comparison of the number of gangrene cases in certain hospitals, and the number appearing upon the sick report. It was to have been expected that when the form of classification of diseases, as well as a new method of registering the cases, was introduced during an active campaign, the first returns would be imperfect.

I think that it would be fair to assume that during the months of July, August, September, and October, 1864, about three thousand cases of hospital gangrene occurred amongst the wounded of the Army of Tennessee, and of this number about one half, or fifteen hundred, were disabled, for the war at least, by the disease. Surely, everything connected with the history and treatment of a disease so destructive to the efficiency of an army is worthy of investigation.

Being a contagious disease, capable of arising whenever the hospitals are crowded with men, wounded when their constitutions are debilitated and broken down by bad diet, fatigue, anxiety, and exposure, we must expect to see hospital gangrene progressively increase as the war goes on, and especially if the disasters of the campaign in Northwestern Georgia should be often repeated.

The evacuation of large tracts of country, and the consequent crowding of the hospitals in the rear, is a fruitful cause of the disease.

CAUSES OF DEATH IN HOSPITAL GANGRENE, AND RESULTS OF POST-MORTEM EXAMINATIONS.

Causes of death in hospital gangrene and results of post-mortem examinations.

When hospital gangrene progresses unfavorably, the constitutional symptoms become progressively more grave, and the fatal termination is generally announced by a feeble, rapid pulse, extreme prostration, twitching of the tendons, vomiting, hiccough, involuntary dejections, and and ofttimes coma. Many cases, however, die without any derangement of the brain, and the patients are sensible and calm up to the moment of death.

Death from hospital gangrene may result from one or more causes.

1. Effects of the absorption of the

1. *Progressive failure of the powers under the action of the depressing and irritating effects of a large and constantly increasing wound, and of the derangement in the constitu-*

gangrenous matters in producing death.

tion of the blood, and of the nutrition, induced by the absorption of the gangrenous matters and its products.

The following case furnishes a good illustration of this cause of death, and of the progressive failure of the circulatory and nervous systems in many fatal cases of hospital gangrene: —

Case XXXVII. Illustrating the fatal effects of the absorption of the gangrenous matters.

Case XXXVII. John W. Coleman, Company H, 2d Regiment Georgia State Reserves. Native of Oglethorpe County, Georgia. Occupation, farming. Age, forty. Height, five feet eleven inches. Muscular, well-built man. Black hair; black eyes. Dark, sallow complexion. Wounded at Jonesboro', on the 31st of August, 1864. The ball passed through the posterior muscular parts of the left thigh, entering about two inches above the knee joint, on the outer side of the lower third of the thigh, and, ranging upwards and backwards through the large muscles on the posterior of the limb, escaped in the lower portion of the middle third.

The wound was considered comparatively slight, as no important blood-vessel nor nerve was injured, and the bone remained untouched. Was taken prisoner, and placed in a Federal hospital, and remained there two or three days; and from thence was sent to Jonesboro', and was recaptured by the Confederates, or rather abandoned by the enemy, on the 6th of September.

From Jonesboro' was sent direct by railroad to Macon, and remained only one night at the Ocmulgee Hospital, and was transferred the next day (9th of September) to the Empire Hospital. At this time, the external wounds of entrance and exit were quite small, and they were said not to be gangrenous. Shortly after entering this hospital, however, gangrene appeared in the wound of entrance, and spread with steady advance, unchecked by local remedies.

October 18. — Pulse, 100. Patient very nervous, every muscle twitching. Low muttering delirium. Talks to himself, and picks at the bedclothes. When addressed in a firm, distinct manner, or aroused by a gentle shake, gives a coherent answer for a few seconds, but soon wanders and gives inaccurate statements, and in a few moments relapses into the same state of low muttering delirium, talking to imaginary persons, and about his home, and picks, with his emaciated, trembling hands, at the bedclothes, and motes in the air. Complexion of an unhealthy, leaden hue. Tongue red and dry. Skin hot and dry, and has a harsh, unpleasant feeling to the touch. Bowels rather loose.

Up to the present time, however, his bowels have not been specially deranged. No appetite. Great nervous and muscular prostration.

The wound presents a most distressing and disagreeable appearance. On the outer surface of the left thigh, it extends from near the knee

joint upwards for eight inches, and is seven inches in diameter. The muscles are denuded, and the gangrene is extending along the everted and ragged and purplish edges. The surface of the wound presents a grayish and bluish appearance, except over the largest muscles, which appear to be cleaning off to a certain extent, and present a more purplish-red color. The color of the denuded muscles is far different from the florid, bright color of healthy muscles; it is paler, and of a dirty, unhealthy hue.

The internal wound (point of exit of the ball) is separated from the larger external wound (or rather, the wound upon the outer parts of the thigh) by a portion of sound skin, and is about two inches in diameter. The smaller wound upon the internal surface of the thigh presents a more healthy appearance than the external wound. As we have before shown, it is by no means uncommon for the two wounds upon the same limb to present different conditions, one being gangrenous and the other covered with healthy granulations. There are cases at the present time in this hospital, in which the original wound is healing, whilst the bed-sores resulting from pressure are gangrenous, and are rapidly destroying the patients. This will be illustrated more fully in this chapter. Such facts are important in their bearing upon the theory of the disease, and also upon the mechanical and constitutional treatment.

The wound in this case emits a most powerful and overpowering stench. It makes a decided impression upon the organ of taste; and the clothing, after remaining a length of time in the atmosphere of the small tent in which this patient lies, partakes strongly of this disgusting odor.

Tongue slightly furred, and of a deep purplish and bluish color. As far as my experience extends, this is a most unfavorable sign in this disease, and indicates serious derangement of the blood and circulation.

Examination of Urine. — This should be considered as approaching very nearly to the urine discharged during starvation in hospital gangrene, for this patient has no appetite whatever, and scarcely eats anything.

Amount of urine collected during twenty-four hours, from October 17, 11 A. M., to October 18, 11 A. M., 560 CC. = grains 9,014.04. Deep-red color. Specific gravity, 1,022. In the morning after the completion of the collection, the night having been cold and frosty, a heavy yellow deposit of granular amorphous urates, chiefly urate of ammonia. The reaction of the urine was strongly acid at the time of the formation of this deposit. The vegetable cells and animalcules which had been so abundant in this disease during the hot weather, were not present in this during the colder weather, even forty-eight hours after its passage. Upon standing longer, however, they gradually formed. Carefully tested for grape sugar; none discovered.

ANALYSIS OF URINE, NO. 87.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	9,014.04	
Urea	349.27	38.74
Uric acid	8.51	0.94
Free acid	25.00	2.88
Phosphoric acid	20.69	2.29
Equivalent of phosphorus in phosphoric acid . . .	9.09	1.06
Sulphuric acid	20.74	2.307
Equivalent of sulphur in sulphuric acid	8.29	0.92
Chloride of sodium	8.62	0.95
Equivalent of chlorine in chloride of sodium . . .	5.21	0.51

The treatment of this patient now consists of tincture of muriate of iron, gtts. xv.; quinine, grains iiss.; chlorate of potassa, grains iv., four times a day. Wound touched with nitric acid, and washed with Labarraque's solution of chlorinated soda.

October 19. — Patient very nervous. Hands tremble incessantly. Continues in the same low muttering delirium. Pulse rapid, small, and feeble. No improvement of the wound. Keeps the affected limb bent, and appears to be unable to straighten it, on account of the contraction of the muscles. The denuded muscles of the thigh in the wound quiver continually. This quivering is greatly increased whenever they are touched, or when any caustic application is made to the raw surface. Tongue slightly coated with fur at the root; body and tip clean, and of a purplish and bluish unhealthy aspect.

This patient complains of little or no pain, and never expresses a single want. When I addressed him, and drew his attention, he spoke in a most cheerful manner, imagining himself at home and with his old companions, grasped my hand, and continued talking for several minutes about his family and friends. A change then passed over his cheerful countenance, and he appeared like one bewildered and lost, and attempting to discover his true situation, and to recognize some familiar face or object. This poor fellow appears to be wholly unconscious of his most distressing condition. The offensive odor from his wound does not at all disturb him. Treatment continued.

Examination of Urine. — Amount of urine collected during the past twenty-four hours, up to 11 o'clock A. M., 680 CC. = grains 10,962.15. Specific gravity, 1,024.5. Heavy deposit of brownish-yellow granular amorphous urates in the morning after the cooling of the urine (cool, frosty weather). Under the microscope, the granules presented a bright orange-red color. The purpurine formed a beautiful pink layer upon the deposit, and also upon the bottom and sides of the vessel.

ANALYSIS OF URINE, NO. 38.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	10,962.15	
Urea	439.82	40.12
Uric acid	12.92	1.17
Free acid (twenty-four hours after collection) . . .	31.41	2.95
Phosphoric acid	33.51	3.05
Equivalent of phosphorus in phosphoric acid . . .	14.73	1.59
Sulphuric acid	25.65	2.33
Equivalent of sulphur in sulphuric acid	10.26	0.93
Chloride of sodium	10.47	0.95
Equivalent of chlorine in chloride of sodium . . .	6.34	0.57

October 25. — Continues in the same miserable, nervous state, with rapid, feeble pulse, depressed nervous and muscular forces, and low muttering delirium. Skin warm and dry. Hands and muscles tremulous. The ash-colored and gray gangrenous slough has disappeared from a considerable portion of the surface of the denuded muscles, but the destruction of tissue still continues at the lower and upper borders of the wound, which continues to emit a most noisome and disgusting stench. The raw muscles quiver continuously. The destruction of tissue has been very great, and the popliteal artery is nearly exposed. Pulse 98, small and thready. Tongue bluish and purplish. Bowels regular. The patient now has sore throat, and complains of difficulty and pain in swallowing. The mucous membrane of the fauces and tonsils are covered with small white ulcers.

This day I made the following outline sketch of the wound upon the external surface of the thigh. This will give a general idea of the size and position of the wound. (Plate No. XXII.[1])

October 30. — Continues to grow worse. General symptoms the same. The local and constitutional treatment alike fail to arrest the disease or restore the wound to a healthy condition.

November 1. — Intellect still dull and wandering; general symptoms and condition unchanged, except for the worse. Tongue dry, and coated with cracked flakes of white fur. Throat sore, with small white ulcers. Pulse 112, and very feeble. Dusky, leaden complexion. Dull, dejected eyes. Destruction, dissection, and denudation of the muscles of the thigh very extensive, and still continue; there are still gangrenous sloughs in the upper and lower portions of the wound. Up to the present time, no granulations have appeared upon any part of the denuded muscles; and the wound has discharged no pus, but a filthy, fetid sanies. The odor of the wound continues to be foul and disgusting in the extreme. Has no appetite, and continues to lose flesh, and is now

[1] Omitted.

wasted to a skeleton. No bed-sores upon the back as yet, although the parts upon which the body rests look as if they would soon ulcerate. The ground of the tent which this patient occupies is situated in a sink or natural drain, somewhat lower than the surrounding portions of the hospital grounds; and when much water falls, it rushes through this tent, and it has been necessary to open a drain directly through the tent. In fact, the entire hospital grounds are low and damp, and subject to overflow during a hard rain. As the ground slopes towards a small stream about two hundred yards distant, the water during heavy rains rushes under many of the tents. I have observed that, after heavy rains, when the soil was saturated with water, and the atmosphere with the vapor steaming up from the uncovered ground, the gangrene cases almost all progressed unfavorably. The damp ground floor is one great objection to the use of tents in hospital gangrene.

November 5. — Pulse 140, very feeble and weak. Patient reduced to a mere skeleton. The muscles are almost entirely denuded from the bone; and on the inner side of the thigh, especially at the lower portion of the popliteal space, little else than the skin remains. The circumference of the wound still increases slowly, and the gangrene is still present. The denuded muscles present a smooth, pale, red color, with little discharge. Bowels running off.

Low muttering delirium, with trembling of the muscles and picking at the bedclothes, continues. Patient gradually sinking; cannot hold out much longer.

November 6. — This patient died in the evening. The exhausted powers sank very gradually, and almost by imperceptible stages, into death.

2. *Repeated hemorrhage from the blood-vessels exposed and eroded by the gangrene.*

2. Death in hospital gangrene caused by hemorrhage.

The separation of the dead parts is almost always accompanied with more or less hemorrhage, and in the last stages of the disease there is frequently a bloody oozing from the surface of the denuded parts.

When hemorrhage takes place from the large arteries which require ligation, it happens that, in the severest cases, the coats of the artery are sometimes ruptured by the ligature; and when the hemorrhage is controlled by pressure, the limb becomes greatly swollen, and the progress of the gangrene accelerated. In such cases, whether the ligature and the mechanical means of compression be applied or withheld, an unfavorable issue appears to be almost equally certain.

When the forces have been reduced by the long continued action of the gangrenous poison, a very slight hemorrhage will sometimes cause death.

The cases of Arnold Nowell,[1] and William Martin,[2] which we have already presented in the fourth chapter, illustrate in a clear manner the effects of slight hemorrhages in terminating life, in the depressed state of the system caused by the action of the poison of hospital gangrene.

3. *Entrance of air into veins eroded and opened by the ravages of hospital gangrene.*

3. Death in hospital gangrene caused by the entrance of air into veins eroded and opened by the ravages of the disease.

As far as my observations extend, death from this cause is of rare occurrence. We have already presented an interesting case[3] illustrating this mode of death. By post-mortem examination I have been able to determine the important fact that the blood is frequently coagulated, or rather a firm, fibrous, laminated clot forms in veins surrounded by gangrenous matter. This formation of fibrinous clots in the veins appears to precede the erosion of their walls. And hence, by this process and provision of nature, we do not often have the entrance of air into the veins when they are destroyed by hospital gangrene. We have before shown that the fibrin of the blood is increased above the normal standard, and that, even in the worst cases, the blood is capable of forming a firm clot.

4. *Opening of large joints by the gangrene.*

4. Death caused in hospital gangrene by the opening of large joints.

When gangrene attacks parts in the neighborhood of the hip and shoulder joints, or of the knee and elbow, the disease, all things being equal as to its intensity and the condition of the system, is far more dangerous than when situated upon the middle parts of the thigh, leg, arm, and fore-arm.

The opening of a large joint to the air subjects the patient to the additional irritation of the large diseased synovial membrane; and the surface for the action and absorption of the gangrene is at once greatly increased. The gangrenous matters frequently accumulate within the opened joint, and still further, by their putrefaction and absorption, increase the danger. The membranes lining the articulating surfaces of the bones are finally eroded by the gangrene, and the extremities of the bones themselves are attacked in their most vascular and spongy portions. When the extremity of a bone is thus opened, the gangrenous sanies may descend by gravity, or ascend by capillary action through large tracts of sound bone, and in this way, by the opening of a joint,

[1] Case XI. [2] Case XIII. [3] J. M. Broom, Case XII., Chapter Fourth.

the difficulties of any case may be greatly increased, and in fact rendered hopeless, unless the limb be promptly amputated.

The following case will serve to illustrate the effects of gangrene when it invades a large joint: —

Case XXXVIII. Illustrating the fatal effects of the opening of large joints by the ravages of hospital gangrene.

Case XXXVIII. — F. M. McWaters, sergeant, Co. E, 41st Georgia Regiment, Stovall's Brigade, Cleburn's Division, Army of Tennessee. Black hair, dark eyes, dark complexion; muscular, well-built man. Wounded August 31, by minie-ball; flesh-wound, ball entering the inner portion of the lower third of the left thigh, two inches above the joint. Sent to division hospital the day he received his wound, and remained until next night; then sent to Fair Ground Hospital, No. 2, Vineville, Georgia, and transferred to Empire Hospital, September 16. Gangrene was present at the time of his entrance into this hospital, and the wound was about nine inches in circumference, with a black, hard crust. The wound continued to present a dry, dark crust, notwithstanding the application of nitric acid and poultices, and the gangrene spread rapidly, without any secretion of pus or appearance of healthy granulation until the 2d of October, when there was some appearance of granulation and pus. Ball extracted October 5, from the popliteal space. The usual treatment of tincture muriate of iron and stimulants internally, and nitric acid, chlorinated soda, oil of turpentine, oak-bark poultices, and even the actual cautery, were used with little or no apparent effect.

October 4. — Eight o'clock P. M. Pulse, 104. Respiration, 22. Tongue red and dry. Bowels regular. Temperature of hand, 37.2° C. (99° F.). Temperature of axilla, 39.2° C. (102.6° F.).

October 5. — Eight o'clock A. M. The surface of the wound looks more healthy. Granulations are springing up, and some pus is excreted. The gangrene is still, however, progressing slowly at the upper and lower borders of the wound, and over the knee joint, and the denuded surface progressively enlarges. Wound twenty-four inches in circumference. Pulse, 98. Respiration, 18. Tongue red and moist. Skin moist. Bowels regular. Temperature of hand, 33° C. (91.4° F.). Temperature of axilla, 38° C. (100.4° F.).

Eight o'clock P. M. Pulse, 106. Respiration, 16. Tongue red and dry. Skin dry and warm. Temperature of hand, 38.2° C. (100.8° F.). Temperature of axilla, 40° C. (104° F.).

Examination of Urine. — Amount of urine passed during twenty-four hours, from October 4, 8 P. M., to October 5, 8 P. M., 1,000 CC. = grains 16,025.62. Deep reddish orange color. Specific gravity, 1,017.5. Heavy light-yellow deposit of amorphous urates and prismatic phosphates, with alkaline reaction and strong ammoniacal odor, twenty-four hours after collection.

ANALYSIS OF URINE, NO 89.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	16,025.62	
Urea	412.72	25.75
Uric acic	7.60	0.47
Free acid	alkaline	–
Phosphoric acid	54.82	3.42
Equivalent of phosphorus in phosphoric acid . . .	24.12	1.50
Sulphuric acid	16.80	1.42
Equivalent of sulphur in sulphuric acid	6.72	0.41
Chloride of sodium	46.20	2.08
Equivalent of chlorine in chloride of sodium . . .	27.99	1.12

October 6. — Eight o'clock A. M. Pulse, 108. Respiration, 18. Tongue red and moist. Bowels regular. Temperature of hand, 35° C. (95° F.). Temperature of axilla, 40.2° C. (104.4° F.).

Eight o'clock P. M. Pulse, 108. Respiration, 18. Temperature of hand, 37.4° C. (99.4° F.). Temperature of axilla, 40.4° C. (104.8° F.). Tongue red and moist. Bowels regular.

October 7. — Eight o'clock A. M. Pulse, 101. Respiration, 16. Tongue red and dry. Skin warm. Bowels regular. Temperature of hand, 33.4° C. (92.1° F.). Temperature of axilla, 38.5° C. (101.3° F.).

Eight o'clock P. M. Temperature of hand, 33° C. (91.4° F.). Temperature of axilla, 38.5° C. (101.3° F.). Pulse, 104. Respiration, 18. Tongue red and dry. Bowels regular.

October 9. — Nine o'clock A. M. Pulse, 91. Respiration, 18. Tongue dry and red. Bowels regular. Temperature of hand, 38° C. (100.4° F.). Temperature of axilla, 38° C. (100.4° F.).

Nine o'clock P. M. Pulse, 110. Respiration, 18. Tongue dry. Bowels regular. Temperature of hand, 37.4° C. (99.3° F.). Temperature of axilla, 38.2° C. (100.8° F.).

October 10. — Nine o'clock A. M. Pulse, 101. Respiration, 21. Tongue red and moist. Bowels regular. Temperature of hand, 38° C. (100.4° F.). Temperature of axilla, 38° C. (100.4° F.).

Eight o'clock P. M. Pulse, 108. Respiration, 22. Tongue red and dry. Temperature of hand, 37.4° C. (99.3° F.). Temperature of axilla, 40° C. (104° F.).

October 11. — Nine o'clock A. M. Pulse, 112. Respiration, 18. Tongue red and dry. Bowels regular. Temperature of hand, 30.5° C. (86.9° F.). Temperature of axilla, 37.2° C. (99° F.).

Eight o'clock P. M. Pulse, 110. Respiration, 18. Temperature of hand, 32° C. (89.6° F.). Temperature of axilla, 38° C. (100.4° F.). Tongue red and dry. Bowels regular.

October 12. — Eight o'clock A. M. Temperature of hand, 30° C. (86°

F.). Temperature of axilla, 37.5° C. (99.5° F.). Pulse, 106. Respiration, 19. Tongue red and moist.

Six o'clock P. M. Temperature of hand, 37° C. (98.6° F.). Temperature of axilla, 40° C. (104° F.). Pulse, 112. Respiration, 16. Tongue red and moist. Skin moist.

During this period the gangrene has progressed slowly, denuding the muscles; and on the 9th, the joint was opened by its erosive action, and the synovial fluid escaped.

October 18. — Tongue tremulous and red. Complexion dusky, with a deep hectic flush upon the cheek. Hands tremulous. Pulse, 92. The wound continues to enlarge slowly. The joint is opened. The raw muscles present an unhealthy, smooth appearance, without granulations, wherever the gray and greenish slough has been removed. Bowels loose; had six evacuations during the past twenty-four hours. Wound emits an intolerable stench. The patient drinks nothing but strong red-oak bark tea, in the place of water, to control the bowels. No appetite. Eats little or nothing.

Examination of Urine. — Amount of urine collected during twenty-four hours, October 17, 11 A. M., to October 18, 11 A. M., 480 CC. = grains 7,726.32. Deep-red color. Specific gravity, 1,022. Heavy light-yellow deposit, consisting of amorphous granulated urates and vegetable cells, many of which presented a dumb-bell shape. These vegetable cells have materially diminished in the urine of hospital gangrene since the commencement of cold frosty weather.

ANALYSIS OF URINE, NO. 40.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	7,726.32	
Urea	303.07	39.22
Uric acid	9.12	1.05
Free acid	15.52	2.008
Phosphoric acid	17.74	2.20
Equivalent of phosphorus in phosphoric acid . . .	7.79	1.08
Sulphuric acid	14.81	1.91
Equivalent of sulphur in sulphuric acid	5.92	0.76
Chloride of sodium	8.87	1.15
Equivalent of chlorine in chloride of sodium . . .	5.37	0.61

October 19. — Up to the present time, the patient appears to have been unconscious of his condition, as well as of the foul stench emitted by his wound. No appetite. Tongue clean, and of an unhealthy red and purplish blue color. Bowels loose. Continues to take red-oak bark tea as an astringent. The purplish leaden hue of the tongue betokens much derangement in the composition of the blood. Wound

still enlarging, and the bones of the joint are exposed in several minute spots.

Examination of Urine. — Amount of urine collected during twenty-four hours, 350 CC. = grains 5,631.22. Specific gravity, 1,022. Deep-red color; clear; no deposit when first passed, as in the preceding specimen; but after standing seventy-two hours, a heavy yellow deposit of granular urates gradually fell, with a few octahedral crystals of oxalate of lime. Immediately after its collection, the urine was tested for grape sugar; no trace.

ANALYSIS OF URINE, NO. 41.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	5,631.22	
Urea	218.29	38.65
Uric acid	7.70	1.03
Free acid	20.21	3.59
Phosphoric acid	8.50	1.509
Equivalent of phosphorus in phosphoric acid	3.74	0.67
Sulphuric acid	10.80	1.91
Equivalent of sulphur in sulphuric acid	4.32	0.76
Chloride of sodium	5.39	0.95
Equivalent of chlorine in chloride of sodium	3.26	0.57

The free acid of the urine appeared to be, to a certain extent, a modified form of tannic acid, derived from the red-oak bark tea, which was the only fluid which this patient was allowed to take to quench his thirst. In testing for phosphoric acid, the urine gave with the perchloride of iron, acetate of soda, and ferro-cyanide of potassium, before the blue spot was formed, a deep bluish leaden color. When the perchloride of iron was added to the urine, it gave a dark, blackish color, as if tannic or gallic acid were present. The phosphate of iron thrown down in the test for phosphoric acid, did not present the reddish-brown color usual in the urine, but a dark brown inclining to black precipitate. The reaction of the urine continued strongly acid for a week or ten days, and even longer.

October 24. — Eleven o'clock A. M. Pulse, 128. Skin hot and dry. No appetite whatever. Has had none since the appearance of the gangrene. Tongue dry and red at the edges, and of a deep purplish blue in the centre. All cases in which I have observed this purplish, leaden hue of the tongue, have terminated fatally.

The wound has reached frightful dimensions, and the patient is rapidly sinking under the effects of the gangrene. Large tracts of the denuded muscles, and of the capsular ligament of the joint, present a slick red appearance, and secrete little or no pus. No granulations are to be observed. From the openings in the capsular ligament of the

knee joint, pus and a thin, fetid, sanious fluid continually issue. The synovial fluid of the joint escaped fifteen days ago. A consultation of surgeons was called at this time by the attendant medical officer, Assistant-Surgeon Calhoun, and the question of amputation debated. It was decided to attempt to save the limb. I was not present at this consultation, but immediately after gave my decided opinion that the leg should be amputated, as the only chance to save the life of the patient.

The limb should have been amputated, without any question or hesitation, as soon as the joint was opened by the gangrene. As far as my experience extends, the opening of the knee or elbow joints by gangrene, has always insured a fatal termination, either from hemorrhage or from the gradual exhaustion of the patient. In such cases, the parts beyond the joint are liable to gangrene of a rapid and destructive character. In such low cases as the present one, after amputation, the spirits of turpentine should be most liberally administered internally, together with alcoholic stimulants and nutritious diet.

I remained the entire day in the tent with this patient, examining his condition, and executing a drawing of the leg and foot. (See Plates XXIV. and XXV.[1])

These sketches will give a better idea of the ravages of the disease, and the appearance of the wound, than a long description.

The left foot, on the outer side, where it had rested four days ago, manifested a blue spot, as if gangrene was about to spread in the parts subjected to pressure. The blue spot gradually enlarged. The advancing lines around the circumference presented a dark purplish blue color, whilst the central portions (those parts first and longest affected) assumed a greenish gray color. The entire foot became much swollen, and the parts around the advancing blue line were much inflamed, and the sound skin presented a bright scarlet blush, which gradually shaded into the deeper purple and blue.

From the central gray and greenish and bluish mass of dead gangrenous tissues, a thin fluid issued.

The drawing, Plate No. XXV.,[2] represents the appearance of the outside of the left foot. The bottom and heel of the foot had been poulticed, and hence the wrinkled appearance. The patient continued to grow gradually worse; gangrene spread over the entire foot, and the case terminated fatally on the 26th in the evening.

This patient retained his senses and intelligence to the last moment. I conversed with him only a few moments before death, and he spoke calmly and intelligently, and cried out with pain when his left leg was touched or moved in the least.

5. *Formation of large bed-sores during the progress of the disease, and the appearance of gangrene in them.*

[1] Omitted. [2] Omitted.

As we have before shown by numerous cases, the tendency of the poison of hospital gangrene, after its absorption, is to the rapid derangement of the constitution of the blood and of the nutrition of the body generally, and by its action the general and capillary circulations are greatly depressed and deranged. It follows from this, that all parts subjected to continuous pressure in this disease, are liable to death. Hence the most scrupulous attention should be paid to the change of posture, and to the friction and stimulation of all parts necessarily subjected to pressure in patients suffering with this disease.

5. Fatal effects of bed-sores in some cases of hospital gangrene.

I have seen a number of cases which appeared to terminate fatally, entirely on account of the gangrenous bed-sores, after all gangrene had been removed from the original wound, in which both granulation and suppuration had been established.

The following case will illustrate this proposition: —

Case XXXIX. Illustrating the fatal effects of bed-sores in hospital gangrene.

Case XXXIX. Thomas Nesbit, private, Company A, Austin's Battalion, Louisiana Sharpshooters. Age, nineteen. Brown hair; brown eyes. Height, five feet eight inches. Native of New Orleans. Has been engaged in active service three years; and during this time has served with the Army of Tennessee, from Columbus, Kentucky, to Atlanta, Georgia. Has enjoyed good health both before and after entering the Confederate army. Has never suffered with the venereal disease. Was wounded for the first time at Atlanta on the 28th of July, 1864. The ball (minie) glanced from the ground and inflicted a slight wound upon the foot, near the instep, and appeared only to take off the skin and slightly to bruise the surrounding parts. No bones were broken, and the field surgeon pronounced it a slight wound. Patient says that he was in very good health at the time of the reception of the wound. Was removed from the battle-field to the division hospital, and remained there only an hour and a half, and was transferred to the railroad station (receiving hospital), where he remained during the night, and started the next day for Macon. The cars were delayed one day and night on account of a raid of Federal cavalry. They were crowded with wounded soldiers, so crowded in fact that many of the men did not have room to lie down; and there was but a poor supply of water, and but little attention to the dressing of the wounds. Entered the Fair Ground Hospital, in Vineville, and the gangrene appeared in his wound about three weeks after. Has been in the Empire Hospital about one month.

The gangrene progressed for a time apparently without any check, and destroyed the tendons of the foot upon the upper or dorsal surface

(extensor tendons) and the flexors have curled the foot under, as represented in the drawing, Plate No. XXVI.[1]

Under the local action of nitric acid, and of other remedies, the gangrene disappeared, and the wound assumed a healthy granulating surface, and discharged laudable pus. The recovery of the patient appeared to be highly probable, when large bed-sores formed upon the back, and took on the gangrenous inflammation. After the appearance of the gangrene in these large diseased surfaces upon the back, obstinate diarrhœa set in.

October 4. — Pale, sallow, dusky hue, with sunken eyes and pinched features. Dejected, wasted, wan countenance. Bowels running off continually. Evacuations watery, and very fetid. Great muscular and nervous exhaustion. Cries like a child, not only whenever his wounds are touched, but whenever anything crosses him. A mere skeleton. Pulse, 112; a mere thread, so feeble as to be counted with difficulty. Respiration, 20.

The wound presents a florid, granulating surface, with thick, greenish, tenacious pus.

I executed the sketch of the appearance of the right (diseased) foot. The heel is becoming gangrenous from pressure, as represented in Plate No. XXVI.[2]

The condition of the wound is not such as to account for the feeble state of the patient.

Large gangrenous bed-sores, emitting a most foul odor, and presenting inflamed, everted edges, and an internal gray and greenish pulpy slough, have formed, and are rapidly spreading and denuding the muscles upon the back and hip.

This patient died a few days after this observation. It appeared evident that this case fell a victim to the extensive bed-sores.

6. *Diarrhœa resulting from the irritant action of the poison of hospital gangrene upon the internal mucous membrane.*

6. Death caused by diarrhœa resulting from the irritant action of the poison of hospital gangrene upon the intestinal mucous membrane.

After the absorption of the gangrenous matter, the immediate cause of death is in many cases of long standing, profuse, and uncontrollable diarrhœa. In the early stages of the disease, the bowels are most generally constipated, and the use of occasional purgatives beneficial; but when the disease has continued for a length of time, and a large surface has been exposed to the action and absorption of the deleterious materials, diarrhœa of an obstinate and fetid character frequently sets in. In some cases the diarrhœa precedes the favorable changes in the diseased structures and in the constitutional symptoms, and appears thus to be of the nature of a critical discharge, the mucous membrane of the intestinal canal

[1] Omitted. [2] Omitted.

acting the part of an emunctory, and eliminating from the blood and lymphatic system the poisons and the deleterious compounds resulting from its action upon the organic constituents of the blood and lymph.

The discharges from the bowels generally present a healthy bilious yellow color, unlike the pea-soup evacuations of typhoid fever. The odor partakes of the nature both of that of fæcal matter and of the gangrenous matter, and is ofttimes overpowering and intolerable.

No uniform lesions of the intestinal canal in cases of hospital gangrene terminating fatally from diarrhœa.

I considered it to be of some importance to determine whether there were any characteristic lesions of the mucous membrane, with its glandular elements, of the intestinal canal, in this diarrhœa, and accordingly subjected the question to the only practical test. As far as my observations extend upon the condition of the intestinal canal in cases of hospital gangrene terminating fatally on account of diarrhœa, there is no uniform lesion of the alimentary canal, beyond the marks of irritation and congestion. In the most obstinate cases, I have observed large tracts of the intestinal mucous membrane, especially in the jejunum, which presented the appearance of healthy mucous membrane, with no marks of congestion or irritation. The marks of irritation and congestion are most striking in the ileum, especially towards the ileo-cæcal valve. The mucous membrane presented a red and irritated appearance, with an arborescent and punctated congestion and injection of the blood-vessels.

I have observed no enlargement nor softening of the glands of Peyer, nor of the solitary glands, nor of the lymphatic glands of the mesentery. Neither is the mucous membrane of the intestinal canal, as a general rule, ulcerated. Ulcerations of the mucous membrane of the ileum and colon have been observed when dysentery has preceded or been engrafted upon hospital gangrene as a distinct disease ; but these solutions in the continuity of the mucous membrane appeared to be in no manner connected with the action of the gangrenous matter during its elimination.

Results of post-mortem examinations instituted upon the Federal prisoners in Camp Sumter, Andersonville, Geo.

In the post-mortem examinations which I instituted upon the Federal prisoners at Andersonville, in the Confederate States military prison, ulcerations of the mucous membrane of the intestinal canal, and especially of the colon and rectum, were present in a number of cases. But they were just as abundant in the cases of diarrhœa and dysentery without hospital gangrene. A careful examination of the causes inducing diarrhœa and dysentery in these

prisoners demonstrated conclusively that the ulcerations in both classes of cases were due to special causes, and that in the gangrene cases they were not at all connected with the special action of the poison.

Gangrene attacked the ulcerated intestinal mucous membrane of the bowels of the Andersonville prisoners.

A fact of interest in these cases of the Federal prisoners was, that the inflamed mucous membrane of the intestines in the cases of diarrhœa and dysentery, arising from bad diet, scurvy, and foul air, frequently took on gangrene, both with and without the existence of any hospital gangrene upon the exterior. The mucous membrane, instead of presenting the bright red color, with the inflamed ulcerations of ordinary cases of diarrhœa and dysentery, presented a gray, greenish, slate-colored, and bluish surface.

After the establishment of hospital gangrene in the intestinal canal, the failure of the powers was rapid, and death terminated the cases, even before the structures could be disintegrated to any extent.

This fact is of great importance in sustaining the proposition which I advanced in the third chapter, namely:—

The poison inducing hospital gangrene is capable of entering the system through the pulmonary and cutaneous systems, and of exciting gangrene in parts which were probably in a state of defective nutrition, degeneration, or inflammation, or of depressed vitality, but which, as far as known, were not exposed in any manner to the direct action of the poisonous matter, and over which the integuments were in an unbroken and uninjured state.

The results of the investigations instituted amongst the Federal prisoners at Andersonville, will be considered more fully in the chapter devoted to the consideration of the causes of hospital gangrene.

In some cases, diarrhœa supervening upon hospital gangrene to be regarded as a critical discharge.

In passing, we will allude to a practical point illustrated by the preceding investigations. If the diarrhœa occurring in many cases of hospital gangrene be of the nature of a critical discharge, physicians should exercise caution and judgment as to the mode in which they attempt to control or check this effort of nature to eliminate deleterious agents from the blood.

When the blood is greatly disorganized, and loaded with injurious compounds, more harm than good will result from locking up with opiates, tannin, sugar of lead, and other astringents, the channel by which the offending matters are naturally removed.

The following cases will illustrate the preceding observations upon the changes of the intestinal canal in hospital gangrene, accompanied with diarrhœa. They will also afford other points of interest, bearing upon the nature and pathology of the disease: —

Case XL. Obstinate and fatal diarrhœa supervening upon hospital gangrene.

Case XL. J. A. J. Shelton, Lieutenant, Company G, 50th Regiment, Tennessee Vols. Occupation before entering service, merchandizing. Wounded at the battle of Jonesboro', Georgia. Right thigh amputated on the field of battle at the lower third.

Received into the Empire Hospital, Vineville, Georgia, August 31, 1864, with gangrene in the stump of right thigh. The stump was much swollen, and at one time discharged a large quantity of fetid, gangrenous, bloody, dark, almost black matter.

On the 8th of October, when I first examined this patient with a view to study his condition, he appeared to be in extremis. Twitching of all the tendons and muscles of the extremities; rapid, feeble pulse, scarcely perceptible, and so small and flickering that it could not be counted. Cold extremities. Sallow complexion. Pinched and ghastly features. The attendant medical officer had directed my attention to this case as one presenting strong symptoms of pyæmia. I was so impressed with his low condition, that all hopes of his rallying from this state were abandoned. It was, however, deemed advisable to administer alcoholic stimulants freely, as they had been discontinued for some time before these distressing symptoms manifested themselves.

Under the hourly administration of small quantities of whiskey, the patient rallied, and for several days appeared to improve; the stump also diminished in size, and appeared to be undergoing some favorable changes.

The discharge, however, from parts of the stump was quite great, and extensive sloughing continued along the back of the thigh. Obstinate and exhausting diarrhœa set in, and the patient died October 23.

Post-mortem. — *Exterior.* — The anterior and upper portions of the wound appeared to be free of gangrene, and presented a granulating surface. The posterior portions of the thigh were in several places gangrenous, and the denudation of skin and muscles had extended for near ten inches up towards the buttocks.

The femoral vein and artery were carefully dissected out. The ligated end of the artery was closed by a firm fibrous coagula, one inch in length, and composed of alternate layers of fibrin. The femoral vein was occluded at its lower extremity, and its diameter for several inches above the wound was greatly diminished. The occlusion of the vein was not accomplished by the formation of a fibrous clot, as in the

case of the artery, but by the firm adhesion together of the walls, thus forming a fibrous ribbon of the formerly hollow blood-vessel. A firm fibrous clot was discovered in the main branch of the femoral vein, which conveyed blood from the parts in the back of the thigh which had been so extensively involved in the slough. This clot was likewise firm, and composed of layers of fibrin. The clot did not completely occlude the vein, and a small stream of blood evidently passed from the parts to which it had been distributed.

This observation is important, as illustrating the mode in which important blood-vessels are sometimes occluded during the progress of gangrene, even for some distance from the seat of the disease. This occlusion may account for the sudden and great swelling which sometimes occurs in hospital gangrene. If the vein be a large one, this occlusion may also accomplish beneficial results by preventing the admission of air and of the decomposing structures and matters, and of pus directly into the blood through the eroded end of the vein in the gangrenous or sloughing wound. It is probable that many cases of gunshot wounds would terminate in pyæmia, if nature did not thus close by fibrinous clots the channels through which the products of the disintegrating tissues might enter. This subject offers a wide field for investigation, and much light might be thrown upon the nature of pyæmia and of sudden blood poisoning, by a careful examination of the blood-vessels in all fatal cases of gunshot wounds. If in large suppurating wounds nature ordinarily prevents the entrance of deleterious matters into the blood by occluding the veins in this manner with fibrinous clots, before their coats are eroded, the question naturally arises, whether in pyæmia the veins have at any time been occluded, and if they have been, what has destroyed the barriers to the entrance of the pus? If the veins have not been occluded, what is the condition of the blood which has prevented the formation of these fibrinous masses? Do not these questions indicate the direction in which we may seek for the explanation of the fact that pyæmia is most likely to occur in the crowded atmosphere of the hospital, and in those the constitution of whose blood has been depraved by bad diet, vicious habits, and foul air, and by unhealthy suppurating or gangrenous wounds? This question will manifestly involve the determination of the effects of foul air, and of various organic matters absorbed from unhealthy wounds, upon the constitution of the blood, and especially upon the quantity and quality of the fibrinous constituent.

Abdominal Cavity. — Spleen enlarged about twice its natural size, but firm in its structure, and changed to the arterial hue when exposed to the action of the atmosphere. Under the microscope, the blood corpuscles and mud of the spleen presented the normal appearance, and no black masses, as in the malarial spleen, were observed. The microscopical examination revealed nothing abnormal in this organ.

The enlargement of the spleen appeared to have been of long standing, and not connected with the gangrene.

Liver normal in size and in the consistence of its structures, and only a little paler than usual. Under the microscope, the liver cells looked pale and devoid of fat in a great measure. This patient was greatly emaciated, a mere skeleton, and the absence of oil globules, or rather the diminution of the quantity usual in cases terminating fatally in acute diseases, before there had been extensive wasting of the tissues, appeared to be nothing abnormal, but simply the effects of the long-continued and progressive consumption of the hydro-carbons of all the tissues. The abdominal muscles were without any layer of fat, and the mesentery and omentum were in like manner without any, or rather with very little fat.

Gall-bladder distended with yellow bile.

Alimentary Canal. — Stomach pale and healthy; mucous membrane pale, and with no abnormal appearance. Mucous membrane of duodenum and jejunum healthy in color and consistence.

The ileum presented many congested portions, especially towards the ileo-cæcal valve. The congestion of the mucous membrane of the ileum was not uniform; many portions presented a healthy appearance.

Plate No. XXVII.[1] represents the appearance of a portion of the ileum, near the ileo-cæcal valve.

The portion from which this drawing was made, was one of the most congested parts of the intestinal tract.

Peyer's and the solitary glands, as well as the mesenteric glands, were unaffected, — neither engorged, enlarged, nor inflamed nor softened.

The ileum contained much tenacious yellow mucus and fetid yellow fæces. Under the microscope, the contents of the bowels presented nothing unusual, or of special interest. No living animalcules were observed.

When the mucous membranes of the intestines were floated in water, and examined with a magnifying power, the capillaries of many of the villi and of the highly-colored spots of the mucous membrane were found to be engorged with red blood. I observed during these examinations no abrasion, ulceration, or solution of continuity in any part of the mucous membrane.

The large intestine was filled with thin, yellow, fetid fæces, and the mucous membrane presented a healthy appearance, without any ulceration.

The diarrhœa in this case appeared to have been due to the irritant action of the matters absorbed from the gangrenous tissues. As we have before remarked, in many cases of hospital

[1] Omitted.

gangrene recovery is preceded and accompanied with diarrhœa, which appears to be salutary in its effects, and leaves no permanent lesion of the intestinal mucous membrane; whenever, however, the bowels are uncontrollable for a length of time in this disease, a fatal issue almost invariably follows.

Case XLI. Fatal diarrhœa resulting from the absorption of gangrenous matters.

CASE XLI. This Confederate soldier had suffered with a gangrenous wound of the left thigh and hip for near six weeks. During the last two weeks of his disease the bowels were affected with a constant and exhausting diarrhœa, and there was low muttering delirium, and great muscular and nervous prostration, and twitching of the tendons, and picking at the bedclothes, as in typhoid fever. In fact, before I examined this case, the attendant medical officer called my attention to it as one of typhoid fever. The discharges of the bowels, however, were different from those of this disease, and the complexion was more sallow and less florid than in typhoid fever. These facts, taken in connection with the extensive gangrene, led me to dissent from the diagnosis, and to pronounce it a case of diarrhœa resulting from the action of the absorbed gangrenous matters. This patient died in the Empire Hospital, October 1, 1864.

POST-MORTEM. — *Exterior.* — Greatly emaciated. Wound on left thigh and hip, about three inches in diameter, with a deep blue and greenish gangrenous surface. Dissection revealed extensive gangrenous disorganization of all the parts surrounding the hip joint. Trochanters and back, and head of femur, and acetabulum, and bones of pelvis immediately surrounding the hip joint, denuded of periosteum. Capular ligament in a measure destroyed. The muscles of the thigh and buttock, around the dead bones and opened joint, disorganized, gangrenous, and infiltrated with the fetid gangrenous matters. The skin over large portions of these disintegrated tissues appeared upon the exterior to be quite sound, and there was during life no change of color and but little swelling to denote the extensive destruction of muscles, ligaments, and cellular tissue. In fact, this state of things was not at all suspected by the attendant physician, who informed me a few days before the death of this patient that the wound was progressing favorably.

Abdominal Cavity. — Skin of the abdomen of a greenish and bluish color, as if the bowels were in a state of mortification. As this patient had suffered with most obstinate diarrhœa, and had died delirious, and as his case had been pronounced to be typhoid fever supervening upon a gangrenous wound, I examined his bowels with great care, from the œsophagus to the anus, in the presence of several of the medical staff of this hospital. When the abdominal walls were divided, the muscles were found to present a blue and purplish color, far different from the color of the muscles in patients who die from other acute diseases, as pneumonia, or even from typhoid fever.

Stomach. — Mucous membrane appeared to be healthy, and not congested. Nothing unusual was observed in this viscus.

Duodenum and Jejunum. — Congested in patches, which presented a bright red punctated appearance. No softening or ulceration was observed in the mucous membrane of the duodenum and jejunum.

The ileum, colon, and rectum presented an arborescent and punctated congestion; and in like manner no ulceration or solution of continuity was observed in the mucous membrane of this portion of the intestinal tract.

The lymphatic glands of the mesentery presented a dark bluish color, and were enlarged and softened.

The glands of Peyer and the solitary glands, on the other hand, were normal in appearance, and presented no evidence whatever of the deposit and softening of typhoid fever.

The bowels, especially the ileum and colon and rectum, contained much fetid yellow fæcal matter. In the color and general appearance of the fæces, however, nothing peculiar was discovered.

Liver. — Pale, but healthy in appearance and structure. Gall-bladder distended with yellow bile.

Spleen. — Enlarged to three times its normal size, and somewhat softened, but not softened to the extent common in malarial fever.

Commentary. — This case illustrated the following points which I have verified in other autopses: —

Commentary.

1. The most extensive disorganization of tissues from hospital gangrene may exist, without manifesting any marked signs during life upon the external surface. This is especially apt to be the case when the forces have been reduced by the absorption of the gangrenous matter, and by an active and debilitating diarrhœa. It would appear as if the thorough poisoning of the blood by the gangrenous matters prevented the occurrence of the usual symptoms of inflammation.

2. The obstinate diarrhœa accompanying this case appeared evidently to be due to the irritant effect of the absorbed poisonous matters upon the intestinal mucous membrane, rather than to any primary or serious lesions of the intestines.

3. From this and other cases, we conclude that the lymphatic glands are sometimes, but not uniformly, involved in hospital gangrene to such an extent as to be enlarged and softened.

7. *Extensive and rapid disorganization of the tissues around the original wound, beneath the sound skin, accompanied by absorption of the gangrenous matters, great nervous and muscular prostration, and obstinate diarrhœa.*

7. Cause of death in hospital gangrene.

The following case furnishes a good illustration of these causes of death in hospital gangrene: —

Case XLII. Illustrating the causation of death by the extensive and rapid disorganization of the tissues, and by the absorption of the gangrenous matters.

Case XLII. John Kelly, Federal prisoner. Wounded and captured at the battle of Chickamauga, September 19, 1863. Age, thirty. Medium size. Height, five feet eight inches. The wound appeared at first to be slight. A minie-ball passed through the external portion of the lower third of the left thigh, just above the knee joint. The femur appeared to have been rudely jarred and splintered upon its external surface, but not fractured by the ball. Whether the joint had been seriously injured, I was unable to ascertain. The synovial fluid does not appear to have been evacuated, as the patient states that he was able to walk about for several days after the reception of the wound. Twelve days after his capture, was transferred from Atlanta to Augusta, Georgia. The patient states that the travel in the cars caused him great pain in the limb, and the agony was intense towards the close of the ride, from the effects of the jolting of the cars.

After his entrance into the Second Georgia Hospital, his sufferings were exceedingly great, and the limb continued to swell. A low, irritative hectic fever made its appearance immediately after the arrival of the patient. Pulse rapid and feeble. Complexion sallow, and slightly jaundiced. Loss of appetite, and nervous irritability and prostration. Tonics, stimulants, and opiates, with nutritious diet, were faithfully administered, but with no beneficial results. The swelling in the wounded limb increased, and the wound, near the left knee joint, discharged much unhealthy pus; and two weeks before his death, a large abscess which had formed in the left groin was opened, and discharged much pus.

After the formation of this abscess, the bowels became loose, and the patient suffered from a most offensive and exhausting diarrhœa. Towards the close of this case, chills and other symptoms of pyæmia made their appearance. Throughout the disease the intellect remained clear. I saw him in the last hours of life, and although pulseless, he spoke in a calm, collected manner. The complexion presented a sallow, jaundiced hue.

This patient died in the morning, November 4, 1863.

Autopsy, *Four Hours after Death. — Exterior.* — Body greatly emaciated. Sallow hue of skin. No external marks of disease, except in the left thigh and leg, which are greatly swollen, considering the emaciated condition of the general system. The lips of the abscess in the left groin present a bluish, greenish, and ashy gangrenous color. The original wound on the outer side of the lower portion of the left thigh, above the knee joint, appears to be nearly healed.

Thorax. — Lungs healthy. Heart and great blood-vessels normal.

Abdominal Cavity. — Liver enlarged and slightly indurated, and of a light brownish-yellow color, the upper surface showing evident marks of congestion of the inter-lobular veins; edge of right lobe appeared to be much congested. Internally there were no evidences of congestion; in fact the cut surface presented rather an ensanguined appearance. Microscopical examination confirmed the view which I expressed during the post-mortem, that the liver was partially cirrhosed, and in a state of fatty degeneration. Under the microscope, numerous large oil globules were visible in the secreting cells, as well as in the fibrous tissue and around the capillaries. The proper reagents extracted large quantities of fat from the liver. In fact it was thus demonstrated that the great bulk of this organ was fat.

Gall Bladder. — Apparently healthy, and distended with light-yellow bile. Plate No. XXVIII.[1] was painted with the natural bile.

There appeared to have been no absence of bile in the alvine evacuations during life, and it was abundant in the contents of the bowels after death.

The condition of the liver was by no means the result of the gangrene, or of the causes producing death, and was without doubt of long standing; neither was it related in any perceptible manner to the obstinate diarrhœa. A very fair degree of health may exist together with such a state of this organ, which is comparatively common in those of intemperate habits. Great and small omentum healthy.

Spleen. — Enlarged and indurated. Under the microscope, I was unable to detect any of the altered blood corpuscles and hæmatin which characterize the splenic mud of malarial fever. The enlargement of the spleen did not appear to have been recent. After careful examination of the organ, I came to the conclusion that the enlargement was in no way due to the cause of the disease and death of this patient, and was most probably of several years' standing. The texture of the spleen was even more firm than in health; and in this respect as well as others, this organ was wholly unlike the enlarged softened spleen of malarial fever or of typhoid fever. The spleen changed to a bright arterial color when exposed to the atmosphere.

Pancreas. — Normal in size, and healthy in structure.

Stomach. — Distended with bile and ingesta, and appeared to be healthy. The mucous membrane was pale, and there were only a few spots, of a bright reddish tinge, in the more dependent portions, the slight congestion in these parts being referable to gravitation of the blood.

Small Intestines. — From the stomach to the ileo-cæcal valve, presented both externally and internally a healthy appearance. The glands of Peyer, as well as the solitary glands, presented a healthy appearance, and were not in the slightest degree enlarged or softened.

[1] Omitted.

When the mucous membrane was floated in water, and viewed under a magnifying glass, the villi of the intestines appeared to be normal.

Mesenteric Glands. — Somewhat enlarged, but firm, and with no marks of disease. The softened condition of the mesenteric glands, as well as the peculiar deposit characteristic of typhoid fever, were nowhere found. The enlargement and induration of these glands, as well as of the spleen, may have been due to a previous attack of typhoid fever, many months or even years before.

Large Intestine. — Somewhat congested, but without any ulceration or abrasion of the mucous membrane. The fæcal matters, throughout the intestinal canal, were of the normal yellow color, and, with the exception of consistency, presented nothing unusual except in the fetid odor. When the mucous membrane of the intestines were floated in distilled water, and viewed under a strong magnifying glass, I was unable to detect any alteration in the tubuli or solitary and agminated glands, and no abrasions of the mucous membrane.

Examination of Left Thigh. — The thigh was laid open from the crest of the ilium to the knee joint. All the muscles of the thigh and buttock were affected with hospital gangrene. The femur was denuded of periosteum, and the muscles were detached from the bone. The muscles possessed but little strength, and could be ruptured by slight traction. The muscles presented a purplish and bluish green color, inclining to black in some parts, and in others a greenish-gray color.

Plate No. XXIX.[1] represents the appearance of a portion of the vastus extensus muscle, which was simply pulled away, being detached with little or no force.

The connective cellular, or areolar connective tissue of the muscles, together with the tendons, appeared to have resisted the disintegrating action of the gangrene to a greater extent than the sarcolemma which appeared to be completely broken down in many parts. In the region of the abscess, some pus was found, also in the neighborhood of the knee joint, as well as within the joint itself; and it would appear as if the pus had, before the spread of the gangrene, burrowed amongst the muscles, and thus prepared the way for the rapid and extensive spread of the gangrene. Under the microscope, the muscular tissue appeared to be almost completely disintegrated, with nothing but the areolar connective tissue remaining. Granules, crystals of triple phosphate, crystals of hæmatin of the decomposed blood, together with broken capillaries and blood-vessels, meshes of fibrous tissue, oil globules, and irregular fragments of muscular tissue partially decomposed, with irregular striæ, composed the mass of gangrenous muscular tissue. No pus globules were found in the gangrenous muscles. The presence of crystals of triple phosphate in great abundance, presented at once a great departure from the composition of the healthy muscular substance, and

[1] Omitted.

led me to infer that this gangrenous muscular mass had lost its normal acid reaction, and was now alkaline. As soon as the litmus red was applied to the gangrenous mass, it changed to a decided blue, thus confirming the microscopical examination. It was very evident that this large number of prismatic crystals of triple phosphate could be formed and exist only in an alkaline fluid. The juices flowing from the gangrenous muscles presented a dirty greenish and yellowish appearance, as represented in Plate No. XXIX.[1]

Plate No. XXX.[2] represents the appearance of the decomposing, gangrenous, muscular matter from the muscles of the diseased thigh. The odor from this gangrenous matter was very fetid and disgusting. When a rod dipped in hydrochloric acid was held over these disintegrating muscles, heavy white fumes were formed of the chloride of ammonium.

The knee joint was distended with pus, and the articulating surface of the femur presented several black carious spots, and the entire shaft was dark colored and apparently dead. The leg and foot were much swollen, but gangrene had not involved the textures below the knee. The muscles throughout the body generally presented a leaden, unhealthy hue, far different from the florid hue of health.

The exhausting diarrhœa which appeared to be the immediate cause of death, was due to the absorption of the gangrenous matter, and its action upon the intestinal mucous membrane.

Case XLIII. Illustrating the 7th mode of death by hospital gangrene.

Case XLIII. In the case of a Confederate soldier, wounded in the upper third of the left thigh, at the battle of Chancellorsville, who died with an obstinate and profuse diarrhœa, I found the intestines, as in the preceding case, healthy in appearance, and the solitary and agminated glands in like manner normal. In this case the femur had been fractured, and had been united by a large amount of callus. The ball was found flattened, and lying against the callus. The cause of constant irritation, and which prevented the wound from healing, was a small section of the femur, about one inch in diameter, entirely detached and dead. Hospital gangrene had attacked this wound, as in the preceding case, and the parts around the dead bone presented livid, purplish, blue, green, and grayish colors.

Liver. — Healthy.

Spleen. — Enlarged but indurated, and fully as firm as the spleen of health. The pulp did not differ in microscopical characters from that of health, and contained no hæmatin, and changed to the arterial hue when exposed to the atmosphere.

8. Mortification of internal organs

8. *Mortification of internal organs, induced by gangrenous matter absorbed from the local disease.*

The absorbed gangrenous matter may in certain cases

[1] Omitted. [2] Omitted.

Induced by gangrenous matter absorbed from the local disease

excite mortification of important internal organs. The development of gangrene within important internal organs may take place rapidly, and sometimes without the manifestation of such symptoms during the life of the patient as would indicate the true nature of the disease. It is probable that in many of these cases, the organ which becomes gangrenous was previously in a diseased state, either of active inflammation or of progressive degeneration.

In the case of Hollingsworth, which occurred in the Ocmulgee Hospital (reported at my request by Assistant-Surgeon F. A. Anderson, and given at length in the third chapter of this volume), the lungs were in a state of pneumonic inflammation, before the introduction of the gangrenous poison into the system by direct application of the matter to a blistered surface. I examined this case during life, and inspected the lungs carefully after death, and it appeared more than probable that death resulted from the action of the absorbed gangrenous matters upon the previously inflamed lung. Previous to the application of the gangrenous matter to the blistered surface upon the chest, the patient was improving. As soon as hospital gangrene manifested itself in the blistered surface, the pneumonic symptoms increased in intensity. The breathing became labored, and the bronchial tubes became so filled with fluid that a laborious churning sound was emitted. From the infiltration of the lungs and consequent increase in size, the thorax appeared to be preternaturally distended. The cheeks lost the bright florid flush so characteristic of pneumonia, and the whole countenance assumed a most unpleasant, sallow, dusky, cadaverous hue. After death, the lungs were found to be infiltrated with serous fluid, softened, and, in many circumscribed portions, in a state of incipient gangrene.

Such cases present points of great practical importance.

If the poison of hospital gangrene is capable of transmission through the atmosphere to inflamed surfaces, cases of pneumonia should never be treated in the same ward, or in close proximity with the disease.

The following cases, reported at my request by Assistant-Surgeon F. A. Anderson, of the Ocmulgee Hospital, demonstrate the liability of the lungs in pneumonia to take on hospital gangrene, when the patients are treated in the same ward with gangrene cases: —

CASE XLIV. Thomas Rains, 5th Georgia Reserves. Age, forty-nine. Occupation before entering service, farming. Admitted into Ward No. 7, October 30, 1864, having suffered with pneumonia about fifteen days. After remaining in this ward amongst the cases of gangrene, his symptoms became more grave. Great prostration. Pulse, 130. Complexion very sallow. Brilliancy of eyes. He did not cough very much. Expectoration inconsiderable. Upon examination, dullness and bronchophony right side of chest. Complained of no pain, but at every expiration there was a short moan, or grunt, which he said was entirely unavoidable. Patient not delirious, but very restless, depressed, and anxious. For two hours previous to death, respiration appeared to be entirely voluntary. Very marked distention of thorax and abdomen. Died November 4.

Case XLIV. Illustrating the production of death, by the mortification of internal organs.

Post-mortem. — Upon opening the thorax, a very considerable quantity of gas escaped, also some serum. The anterior portion of the lower and middle lobes, in the suppuration stage; posterior portion of the same dark and indurated, presenting dark and very much softened spots. The left lung normal, with the exception of numerous minute extravasations. The lungs emitted an offensive, gangrenous smell, resembling that accompanying rapid decomposition. Liver normal. Enlargement and softening of spleen. Numerous extravasations throughout the intestinal canal. Very marked in the large bowel.

CASE XLV. Arthur (negro man), about forty years of age; from fortifications around Macon. Was admitted into Ward No. 11, about the 1st of November, with pneumonia, and died on the 4th of November.

Case XLV. Illustrating the 8th mode of death in hospital gangrene.

Post-mortem. — Upon opening the thorax, escape of gas. Left lung normal, with the exception of numerous hemorrhagic spots. Right lung a mere slip, occupying about one fourth of the cavity of the right side of the thorax, the lower lobe being excavated at its under side by a large, dark, and very offensive ulcer, large enough to receive a hen's egg. The whole lung was a mass of broken down, offensive, black structure. This dark purple color was fixed; exposure to the air for a length of time did not produce any change. The liver very much enlarged, and pushing the diaphragm well up into the cavity upon this the right side of the thorax.

Spleen very much enlarged and softened, the finger readily passing through it upon slightest pressure.

The intestinal canal presented numerous extravasations of blood throughout the small and large bowel. This was more prominent in the transverse and descending colon, some of the spots being ten or twelve lines in diameter. No ulceration of mucous membrane of intestines. It appeared as though this condition must have taken place but a short time previous to death.

Similar results observed at Bilboa, by Dr. Hennen.

In the military hospitals at Bilboa, upon dissection after death, the disease was not found to be confined to the immediate parts, but frequently spread much further than external appearances indicated, as a diseased track was often found running up into the groin or axilla, and completely dissecting the muscles and great vessels. When the disease had occupied the outside of the chest, Dr. Hennen found the lungs in two cases, and the pericardium in a third, covered with gangrenous spots, and when the parietes of the abdomen had been attacked, he often observed the same appearances in the liver.

9. *The invasion of organs essential to life, by the direct destruction of intervening structures.*

9. Cause of death in hospital gangrene. The invasion of organs essential to life, by the direct destruction of intervening structures.

When gangrene attacks the stump after amputation at or near the shoulder joint, the disease may progress along the cellular tissue into the cavity of the thorax, and invade the pulmonary structures, and thus produce a rapid fatal termination. I have seen the lungs thus attacked also in a case of resection of the humerus, near the shoulder joint. I have observed that in those cases in which hospital gangrene attacks the lungs, the complexion immediately assumes a most cadaverous, sallow hue. When gangrene attacks the tissues in the groin, it may penetrate the abdomen, and speedily cause death. In like manner, when the scrotum and testicles are attacked by the disease, it may penetrate the abdomen. During the present war, I have seen three cases of gangrene of the scrotum and testicles, in which these organs were entirely exposed, and even destroyed. Each case terminated fatally.

10. *Pyæmia.*

10. Pyæmia supervening upon hospital gangrene.

It sometimes happens that when the gangrene appears to be disappearing from the wound, and after the appearance of granulations and the formation of pus, this fatal disease supervenes.

It is a subject for interesting investigation, to be settled only by carefully recorded cases and statistics, whether pyæmia is more common in cases of hospital gangrene than in those cases in which the wounds present the appearance of ordinary suppurative inflammation. It is reasonable to suppose that all depressing causes which tend to produce such a state of the system as favors the rapid disorganization of the structures, would favor the production of pyæmia. This question will be considered more fully hereafter; and we will proceed at once to the more important practical illus-

trations of the relations of gangrene to pyæmia, as well as of the true characters of the latter disease.

Case XLVI. Illustrating the supervention of pyæmia upon hospital gangrene.

Case XLVI. Ira Parker, private, Company G, 1st Texas Regiment. Age, twenty-three. Light hair; gray eyes. Height, five feet eight inches. Occupation before entering the army, farming. Patient states that he has never had typhoid fever, nor any venereal disease; had chill and fever five or six years ago. Has been in the Confederate army two years, and during that time has not been sick. Was wounded before in Kentucky; the wound healed rapidly, and gave no trouble.

Wounded at battle of Chickamauga, September 19, 1863. Ball entered three and one half inches above external malleolus of right leg, and passed through the muscles and out on the opposite side, two and one half inches above its entrance. The wound was considered by the examining surgeon as a simple one of the tissues, not involving either the bones or the important nerves and blood-vessels.

The patient was transferred on the railroad to Augusta, and entered the Second Georgia Hospital. His general health appeared to be good at the time of his admission, and the wound was thought to be progressing favorably until the 1st of October, when the patient complained of severe and darting pains in the wound, which became red and swollen. These changes in the injured parts were accompanied with fever, which was ushered in by no perceptible chill.

On the 5th of October the wound presented the pulpy, gray, and green slough of hospital gangrene, with swollen, livid, and everted edges. The case was treated constitutionally with tincture of the sesquichloride of iron and sulphate of quinine, and nutritious diet; and locally with a saturated solution of sulphate of copper, without any marked improvement in either the constitutional or local symptoms.

November 2. — Pale, anæmic, with the sallow, leaden hue characteristic of some cases of hospital gangrene. The largest wound in the gastrocnemius muscle is oval in shape, about two and one half inches in its longest diameter, which corresponds with the length of the muscle, and about two and one half inches in its transverse diameter. The calf of the leg is much swollen. The wounds of entrance and exit are separated by a small strip of intervening tissues.

In portions of the wound, especially where the gangrene still exists, the edges are swollen and everted. In the healthier portions, the edges present a more natural appearance. The parts around the wound are purplish red, indurated, and much swollen. Pus issues from those portions of the wound which are granulating, whilst in other parts the gray and green slough of hospital gangrene is still present; and here no true pus appears to be forming. The odor of the wound is fetid and disagreeable.

One o'clock P. M. Pulse 118, small and feeble. There appears to be great depression in both the general and capillary circulations. Respiration, 18. Tongue clean, smooth, and moist, but redder than in health. Patient nervous and depressed. Bowels costive. Appetite poor. Temperature of hand 33° C. (91.4° F.). Temperature of axilla, 40.5° C. (104.9° F.). The hand which had been lying by his side felt quite warm when I first placed my hand upon it; but after its removal from the trunk, it rapidly lost its heat. This indicated the feeble nature of the circulation in the extremities.

November 3. — Symptoms continue unchanged.

Examination of Urine. — Amount of urine collected during twenty-four hours, up to November 3, 1 o'clock P. M., 850 CC. = grains 13,407.85. Specific gravity, 1,023.5. Deep orange, inclining to red color; in fact, it may more correctly be termed light-red. No deposit at the end of thirty hours; only slight turbidness.

ANALYSIS OF URINE, NO. 42.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	13,407.85	
Urea	552.39	33.71
Uric acid	10.48	0.77
Free acid (thirty hours after collection of urine) . .	29.45	2.19
Phosphoric acid	31.41	2.38
Equivalent of phosphorus in phosphoric acid . . .	13.82	1.03
Sulphuric acid	34.98	0.26
Equivalent of sulphur in sulphuric acid	13.99	1.04
Chloride of sodium	70.68	5.26
Equivalent of chlorine in chloride of sodium . . .	42.78	3.19

November 5. — Nine o'clock A. M. Pulse 96, small. Respiration, 18. Bowels regular. Skin dry and cool. Tongue red about the tip and edges; slightly coated, and moist. Temperature of hand, 31.3° C. (88.3° F.). Temperature of axilla, 37.2° C. (98.8° F.). (Tincture muriate of iron, gtts. x., chlorate of potassa, grains v., three times a day. Saturated solution of sulphate of copper to wound. Nutritious diet.)

November 6. — Nine o'clock A. M. Pulse, 84. Respiration, 18. Tongue slightly coated and moist. Skin moist and warm. Temperature of hand, 32° C. (89.6° F.). Temperature of axilla, 38.2° C. (100.7° F.). Wound covered in parts with a dark, unhealthy slough. Treatment continued. Diet, milk punch, egg soup, and beef tea.

Four o'clock P. M. Pulse, 100. Respiration, 18. Temperature of hand, 31.2° C. (88.1° F.). Temperature of axilla, 39.4° C. (102.9° F.).

Nine o'clock P. M. Pulse 108, small. Respiration, 18. Tongue

clean and moist; smoother than usual, as if there were no papillæ; redder than usual. Temperature of hand, 36.8° C. (98.2° F.). Temperature of axilla, 39.9° C. (103.8° F.).

November 7. — Nine o'clock A. M. Pulse, 96. Respiration, 18. Tongue slightly coated and moist. Skin of trunk dry and warm. Temperature of hand, 34.3° C. (93.7° F.). Temperature of axilla, 39° C. (102.2° F.). Swelling of leg continues to increase, and now extends from lower border of gastrocnemius to popliteal space. Gangrenous parts of wound very tenacious, and not disposed to separate by sloughing. A considerable quantity was cut out with scissors. Treatment and diet continued.

Five o'clock P. M. Pulse, 104. Respiration, 18. Tongue slightly coated, and moist. Temperature of hand, 30.6° C. (87.1° F.). Temperature of axilla, 39.2° C. (102.5° F.).

November 8. — Nine o'clock A. M. Pulse, 100. Respiration, 18. Tongue pale, slightly coated, and moist. Skin dry and warm. Temperature of hand, 31.3° C. (88.3° F.). Temperature of axilla, 38.4° C. (100.1° F.). Sloughs are being detached in large pieces. Wound of exit looking red, and with granulations springing up over its entire extent. Wound of entrance also looking red, with granulations over a considerable portion, with the exception of the region about the upper border. Swelling of leg still continues the same. Treatment and diet continued.

Five o'clock P. M. Pulse, 108. Respiration, 18. Temperature of hand, 30.2° C. (86.3° F.). Temperature of axilla, 39.4° C. (102.9° F.).

November 9. — Nine and one half o'clock A. M. Pulse, 96. Respiration, 18. Tongue red at the tip and edges, coated with yellowish fur, and moist. Skin dry and warm. Temperature of hand, 32.3° C. (90.1° F.). Temperature of axilla, 38.2° C. (100.7° F.). Wound in the same condition as on yesterday. Swelling of calf continues. Considerable pus is now secreted by the wound. Treatment and diet continued.

Eight o'clock P. M. Pulse, 106. Respiration, 18. Temperature of hand, 28.2° C. (84° F.). Temperature of axilla, 39.1° C. (102.3° F.).

Ten o'clock P. M. Patient had a chill.

November 10. — Ten o'clock A. M. Pulse, 100. Respiration, 16. Tongue slightly coated, and moist. Bowels loose. Thin, pale yellow stools. Skin cool and dry. (Tincture of opium, gtts. xxv., administered at once.) Wound continues in much the same condition. Discharges pus. Leg still greatly swollen.

Examination of Urine. — Amount of urine passed during twenty-four hours, 1,000 CC. = grains 16,080.75. Specific gravity, 1,021. Heavy, cream-like deposit of urates, upon cooling. (Cold, frosty morning.)

ANALYSIS OF URINE, NO. 43.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine passed during twenty-four hours	16,080.75	
Urea	492.80	30.64
Uric acid	11.02	0.68
Free acid (immediately after collection)	50.05	3.11
Phosphoric acid	57.28	3.56
Equivalent of phosphorus in phosphoric acid	25.19	1.56
Sulphuric acid	26.06	1.62
Equivalent of sulphur in sulphuric acid	10.42	0.64
Chloride of sodium	63.14	3.93
Equivalent of chlorine in chloride of sodium	38.26	3.37
Chlorine determined directly by nitrate of silver	37.05	2.30

Eight o'clock P. M. Pulse, 112. Skin hot and dry. Very severe pain in the leg. Restless and nervous. (One half grain of morphine.)

November 11. — Continues much the same; has had several chills. Symptoms of pyæmia well marked.

November 12. — Continues to grow worse. Had several chills, or rather fits of chilly feeling.

November 13 and 14. — No improvement. Continues to grow worse.

November 15. — Pale, anæmic, sallow, icteric hue of complexion. Conjunctiva jaundiced. Knee joint of right leg distended with pus. The entire leg and thigh is much swollen. Blood-vessels (veins) upon the surface distended with dark-colored blood. The track of each vein is marked by a purple red inflamed line, shooting up the leg and thigh from the wound in the gastrocnemius muscle. Patient feeble and nervous, with restless, trembling eyes and lips. Depressed, anxious countenance, expressive of great distress and weakness. Features sunken; nose pinched. Tongue tremulous, moist, pale, and smooth, as if the papillæ were indistinct. Appears to be wholly unconscious of his true condition, and complains chiefly of loss of appetite, and of pain in the affected limb. The joint is very tender to the touch, as well as the leg, and the patient cries like a child whenever the limb is moved. There is a peculiar weak, nervous trembling of the muscles of the face whenever the patient speaks. Breath offensive. Wound offensive in the extreme. The entire body appears to exhale a most offensive odor. The patient appears to be entirely unconscious of the stench, and keeps his head covered with the bedclothes, as if he was very chilly. The hands tremble whenever they are stretched forth. The skin has a moist, disagreeable, sticky, clammy feeling, and the integuments of the hands have a wrinkled, shriveled appearance, resembling the appearance of hands which have been long immersed in water. Has had a succession of

chills, followed by profuse sweating. All the symptoms of pyæmia are well marked.

In looking at such a case as this, we are strongly reminded of the description of pyæmia by M. Sedillot:[1]—

"A patient is attacked by suppuration, when suddenly, without any other premonitory symptom, or some days after a hemorrhage, or diarrhœa, a diffuse inflammation, a phlebitis, an erysipelas, or a painful engorgement of a wound, a more or less violent shivering fit comes on. Frequently there is observed a general trembling, chattering of the teeth, a drawing in of the limbs towards the trunk, and a morbid diminution of temperature of the skin; speech is difficult, the words uttered being short and interrupted; the eyes are hollow, and the features contracted; the countenance is of a leaden and yellowish color; the respiration frequent; the pulse small, soft, and rapid, and an instinctive sense of great peril is presented. The shivering ceases after a period varying from ten to forty-five minutes; the warmth of surface returns, and a slight transpiration is established. Erratic shiverings, however, return, and not unfrequently at the same hours as in the first instance; the wound dries up, or the suppuration becomes grayish and fetid; the surfaces of wounds assume a withered, flabby aspect; the bones become denuded, and ill-conditioned ulcers arise or extend. The patient seems as if exhausted by fatigue, and plunged into a kind of coma vigile, with occasional delirium, or into a deep stupor; the inspirations are made laboriously, and become more and more accelerated, so that thirty, forty, and fifty per minute are counted; the breath exhales a purulent odor; subcrepitant râles are heard in the chest, the air also not seeming to attain the minuter bronchial ramifications; the skin becomes daily more earthy, yellowish, generally as if jaundiced; articular pains, with swelling, and intra-synovial effusion, manifest themselves successively in the various joints; one or both of the calves may become the seat of inconsiderable swelling, attended with great suffering; and sometimes severe stitches in the side of the chest force cries from the patient. The tongue becomes dry; the lips and teeth are covered with a fuliginous paste; the belly is tender; the pulse tremulant and rapid; subsultus agitates the limbs; the eye looks dull; the cornea has lost its polish; the bladder is no longer emptied; partial paralyses may manifest themselves; the voice is lost; and the patient dies from the fourth to the eighth day, in a state of extreme emaciation, and after a prolonged agony. These are the most common traits of purulent infection, but it is seldom that we find them all present. . . . .

"Any wounded person having a suppurating wound, in whom irregular shiverings, difficulty and frequency of respiration, a leaden or icteric coloring of the integuments, great prostration of strength, and sudden wasting, manifest themselves, is, in our eyes, the subject of pyæmia. We would deliver the same opinion, if in the absence of shiverings, the above named symptoms were present, together with a drying of the wound, or a changed character in its discharge. The existence of an ascertained phlebitis allows of our pronouncing upon the invasion of pyæmia the moment the local symptoms become complicated with shivering, prostration, yellow coloring of the integuments, and altered respiration. Arthritic pains and effusions, disorders of the nervous system, the typhoid appearance, induration or abscess of the calves, etc., add

[1] *Brit. and For. Med. Chir. Review*, October, 1849.

but additional degrees of certainty to our diagnosis. Not unfrequently we only suspect the existence of pyæmia upon the discovery of already advanced changes, which we cannot explain upon the supposition of the presence of any other disease."

Examination of Urine. — Amount of urine collected during twenty-four hours, from November 14, 9 A. M., to November 15, 9 A. M., 550 CC. = grains 8,847.36. Purplish-red color. The shade of pink is very decided and beautiful. Specific gravity, 1,024. Heavy light-orange yellow, cream-like deposit of urates, with highly colored, large, well-formed, lozenge-shaped crystals of uric acid.

ANALYSIS OF URINE, NO. 44.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	8,847.36	
Urea	398.16	45.00
Uric acid	10.36	1.17
Free acid (six hours after collection)	21.17	2.39
Phosphoric acid	35.57	4.01
Equivalent of phosphorus in phosphoric acid . . .	16.64	1.88
Sulphuric acid	17.92	2.02
Equivalent of sulphur in sulphuric acid	7.16	0.808
Chloride of sodium	8.47	0.95
Equivalent of chlorine in chloride of sodium . . .	5.13	0.58

This sudden diminution of the chloride of sodium appears to be an interesting fact in connection with the sudden accumulation of pus in the knee joint. It may, however, be due in a great measure to the loss of appetite. The nurse states that the patient has taken but little nourishment during the past two or three days, and has subsisted chiefly upon chicken soup, and eggs, and milk punch.

Six o'clock P. M. Pulse 120, vermicular, compressible. The pulse feels as if the artery was quite full, and yet the beat is very quick and feeble, and when pressed, even gently, disappears entirely. Respiration, 26; more labored than his usual calm, quiet respiration. Tongue moist and clean; looks smooth. In a profuse perspiration, which has saturated his shirt. Pale, haggard expression of countenance. Icteric hue of complexion. Conjunctiva jaundiced. Temperature of hand, 38.6° C. (101.5° F.). Temperature of axilla, 39° C. (102.2° F.). In speaking, the voice is feeble, as if crying. Muscles of face in frequent motion, as if suffering occasional pangs of pain. Eyes frequently filled with tears, which trickle down his cheeks. In speaking, the contraction of the muscles of the face give the expression of crying. Swelling of the diseased limb continues to increase.

November 16. — Ten o'clock A. M. Pulse 136, small and feeble; scarcely perceptible. Surface bathed in sweat. Voice feeble and

whining. Intellect apparently enfeebled, but still without delirium. Body emits a most disagreeable odor. Breath very offensive. The odor from the diseased limb fills the entire ward, and resembles the heavy odor of hospital gangrene. Countenance sunken. Features pinched. Breathing labored. Respiration, 20. When asked how he is, complains that he feels weak, and has no appetite. Tongue moist, clean, and pale, with enlarged papillæ, and transparent blisters scattered over the anterior portion and edges of the tongue.

Examination of Urine. — Amount of urine passed during twenty-four hours, November 15, 9 A. M., to November 16, 9 A. M, 700 CC. = grains 11,273.46. Specific gravity, 1,023. Reddish pink color, and strong acid reaction. Heavy deposit of urates immediately after its passage. The deposit was granular, with a few well-formed, lozenge-shaped crystals of uric acid. When this amorphous, granular deposit was treated under the microscope, with acetic and hydrochloric acids, thousands of lozenge-shaped crystals of uric acid made their appearance. For colors of the urine of the patient, see Plate XXX.[1]

ANALYSIS OF URINE, NO. 45.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours .	11,273.46	
Urea	431.20	38.07
Uric acid	11.02	0.97
Free acid (fifty hours after collection)	29.64	2.63
Phosphoric acid	36.65	3.25
Equivalent of phosphorus in phosphoric acid . . .	16.12	1.43
Sulphuric acid	20.40	1.89
Equivalent of sulphur in sulphuric acid	8.16	0.72
Chloride of sodium (mere trace)	2.15	0.19
Equivalent of chlorine in chloride of sodium . . .	1.30	0.11

During the past two days the patient has complained much of a severe pain in his left lung, resembling the pain of pleurisy. The left lung is duller upon percussion than normal, and subcrepitous râle is heard over the chest. Wound of leg discharges large quantities of yellow pus.

November 17. — Eleven o'clock A. M. Pulse a mere thread, 120 a minute. Intellect clear. Complains of loss of appetite and feeling weak. Lies with eyes closed, but answers in a feeble voice when interrogated. Features pinched. Complexion jaundiced and cadaverous. Odor from breath, body, and limb most disagreeable and penetrating. Respiration labored. The limb does not appear to be so much swollen. When the knee is pressed, the patient still complains of pain. There appears to be a slight diminution of the size of the joint. During the

[1] Omitted.

preceding night this patient was out of his head somewhat, and his mind appeared to wander. This was the first wandering of intellect noticed by his nurse.

The patient is evidently in articulo mortis. He gradually sunk, and died at 5 o'clock P. M.

Autopsy in Case XLVI. Pyæmia supervening upon hospital gangrene.

AUTOPSY, *Next Morning, November 18th, Ten o'clock A. M. (Seventeen Hours after Death).* — *Exterior.* — Body much emaciated; sallow, jaundiced hue of entire surface; rigor mortis only moderately well formed. Limbs easily moved, and the rigidity occasioned by death easily overcome. Right leg much swollen, but much less swollen than on the third day preceding his death. During the last forty-eight hours of life the swelling has diminished.

Veins of diseased leg and thigh distended with pus.

Examination of the right Diseased Leg and Thigh. — The superficial veins, the internal and external saphenous veins, and their branches, were dissected out and carefully examined; they were all filled with firmly coagulated blood. The wound on the inner side of the calf of the leg was about three inches in length, and two and a half inches in diameter. The superior portion was covered with soft, greenish and bluish, gray and black fetid gangrenous matter. The wound upon the outer side of the calf, and directly opposite, was larger and more altered. The stream of pus which had flowed so freely during the last three days of life, found its vent through this wound.

Before dissecting the wounds and the adjoining parts, the integuments were removed, and the large blood-vessels of the thigh and leg exposed from their entrance into the pelvis, to the wounds. The femoral and popliteal arteries with their branches were found empty. They were split open and examined in situ throughout their length, and were found to present no pus or clots or blood, and to be healthy in color and structure. The femoral vein was distended with thick, yellow, cream-like pus. The venous branches were in like manner filled with yellow pus. The popliteal vein and its branches, the anterior and posterior tibial veins, were traced to the disorganized tissues, and were in like manner distended with thick, cream-like, yellow pus. At various intervals, but chiefly at the junction of the larger vessels with the main trunk, and also in the region of the semi-lunar valves, clots of blood were found mingled with the pus and firmly attached to the sides of the veins. At such points the walls of the veins appeared to be discolored by the coloring matter of the blood, and to be more softened than in those portions where no clots had been formed. See Plate 4. As each venous branch which ascended from the diseased structures was cut in the dissection and isolation of the main trunk, pure cream-like pus issued. The veins were traced directly to the disorganized tissues of the calf of the leg; and in the diseased, broken-down, diffluent

tissues and pus, the walls of the veins were rotten, and gave way upon the slightest traction. In fact, the strength of the veins throughout the entire extent in which pus was found, appeared to have been greatly diminished, and their walls were easily ruptured. There was no difficulty whatever in tracing the veins directly into the disorganized tissues, which resembled more nearly a semi-fluid mass of greenish pus mingled with darker masses of fibrous and muscular tissue in process of decomposition; and it was demonstrated that their eroded walls and patulous mouths communicated directly with the greenish pus and other products of the diseased tissues.

The veins and arteries were next traced towards the heart. The arteries within the cavity of the abdomen were, as in the thigh, found to be normal in appearance and structure.

The right external iliac vein was distended with pus in like manner with the femoral vein. At the point of its junction with the internal iliac vein, the farther progress of the blood towards the heart was arrested by a firm coagulum of blood. The portion of the coagulum pointing towards the heart was quite firm, whilst the clot gradually diminished in consistency towards the pus, and finally became gradually and completely disorganized and mingled with the pus. This coagulum was not very firm, and was readily broken down upon slight pressure. Beyond this coagulum, no pus was found in the internal iliac, common iliac, nor inferior vena cava. No pus was discovered in the superior vena cava, right side of the heart, nor in the corresponding veins of the left side. The veins were carefully dissected in the left side, from the heart, throughout the thigh and leg, and no clots or pus were discovered in them.

When the blood in the vena cava was emptied by the severing of the vessel and the removal of the heart from the body for more minute examination, the clot in the external iliac kept the pus from flowing towards the heart, and no change took place in the calibre of the distended external iliac and femoral veins and their branches.

The wounds were next more minutely examined. The surface was indurated and surrounded with a black border. The structures of the muscles of the calf of the leg were in some parts softened and broken down into greenish pus, and in others softened and disorganized and discolored, presenting green, gray, bluish, and black colors, with little or no pus, and in other parts the truly gangrenous tissues were mixed up with the yellow pus which had infiltrated the muscles of the calf of the leg throughout their entire extent beyond the wounds.

The joint was filled with thick, tenacious, yellow pus, which under the microscope was found to contain numerous granular masses.

The tibia and fibula were splintered slightly, but not fractured by the ball, and the periosteum was removed from those parts exposed by the wound.

The femur at its inferior portion, just above the condyles, was surrounded by a layer of pus. Small circumscribed collections of pus were discovered in different parts of the muscles of the thigh.

The pus from the knee joint and from the veins was thick, cream-like, and when spread in thin layers rapidly dried, forming a crust; and under the microscope it contained fewer and smaller corpuscles, and more granules, than healthy pus. The pus from a healthy granulating wound was examined at the same time by way of comparison, and contained larger and more numerous corpuscles and less granular matter.

The pus from the femoral vein contained in addition fibrous coagula, and masses which resembled particles of decomposed muscular structure.

When the external iliac, femoral, and popliteal veins were opened throughout their entire extent, the coagula appeared to have formed chiefly about the semi-lunar valves, as represented in Plate 4. The mouths of those veins which came from sound structures were plugged up with coagula of blood, whilst those branches which came from the diseased structures poured out pus.

The femoral vein, near where it is continuous with the popliteal, and where several branches were received, and where there were semi-lunar valves, was much distended, and presented upon its exterior a dark blue, gangrenous appearance. The enlarged size appeared to have been due to the formation at this point of a large clot, which resisted for a time the passage of the pus towards the heart, and the final disintegration of this clot, and the consequent injury to the venous walls. This portion of the femoral vein is represented in Plate 4, 1, 2.

The remnants of the coagula at the mouths of several vessels, and also attached to the semi-lunar valves, were here visible. The internal surface of this portion of the vein was covered with a tenacious fibrinous exudation of a greenish-yellow and bluish-gray color, as represented in Plate 4, 1, 2, which adhered with tenacity to the internal surface of the vein. When this was scraped off, the walls of the vein presented a grayish-blue and black color, and evidently appeared to be gangrenous. The odor of the pus, as well as of this portion of the vein, was similar to that of tissues affected with hospital gangrene. Several similar spots in the region of the semi-lunar valves where clots had formed, were discovered in the branches of the femoral and popliteal veins. The tissues surrounding these portions of the femoral vein and its branches were discolored and softened as if gangrene was commencing, and had been induced by the condition of the vein, and the transudation through its walls of gangrenous matter. These spots were situated at various distances from the diseased structures; some of them were in the upper portion of the thigh.

These facts are important, as illustrating the mode in which an entire limb might become gangrenous by the absorption of the matter from the veins.

The dark gray, green, and blue and black portions of the exudation and of the semi-lunar valves, and of the walls of the veins, were found to consist of numerous granular masses, with dark masses of the altered hæmatin of the blood, together with pus globules and masses of fibrous tissue, broken capillaries and fragments of muscular tissue.

The Plate No. 5 represents the appearance of these gangrenous products.

The dark blue, green, gray, and blackish masses of muscular tissue in the region of the wound presented under the microscope a similar appearance to that represented in Plate No. 5. In fact, the dark blue color of the muscles appeared to be due to the presence of innumerable black masses of the coloring matter of the blood. Many of these particles presented a smooth angular fracture, as if they were crystallized. These flakes did not differ in appearance from those which are found in great abundance in the malarial spleen. In the preceding plate,[1] representing the dark pigment granules or altered coloring matter of the blood, from the effused matter and thickened disorganized portion of the semi-lunar valves of the femoral vein, the magnifying power employed was four hundred and thirty diameters.

The reaction of the gangrenous matter and structures was decidedly alkaline.

The reaction of the blood in the heart was slightly alkaline.

The reaction of the pus in the veins was alkaline.

CHEST. — *Heart.* — Color, structure, and valves were normal.

Pericardium and pericardial fluid presented a normal appearance.

Examination of Blood contained in the Cavities of the Heart. — The blood in the vena cava and right auricle and ventricle of the heart was fluid, and coagulated slowly when removed. During coagulation the colored corpuscles settled towards the lower portion of the blood, and left above a bright yellow, golden, transparent clot.

The right ventricle contained a golden-colored, tenacious, fibrinous clot, free from colored blood corpuscles, and firmly attached to the columnæ carneæ and cordæ tendineæ. Similar fibrinous bodies were also found in the left side of the heart, but they were small in size. No clots were found in the aorta and its branches. Under the microscope, the blood of the heart was discovered to contain an unusual number of colorless corpuscles, and numerous corpuscles which could not be distinguished from pus globules.

Lungs. — Pleural surface of left lung, coated with a recent golden-colored fibrinous exudation, which resembled a layer of golden-colored wax. The lungs contained, in various portions of their structures, yellow, cheese-like deposits resembling some forms of tubercular matter, these masses were of various sizes, from the size of a chestnut to a wal nut. Under the microscope this yellow deposit was found to consist

of numerous cells, some of which were caudate and spindle-shaped, also numerous granules and some oil globules. The organic cells resembled some forms of the exudation corpuscles of inflammation, and were in all cases nucleated. They appeared to have been arrested in their development, as no fibres could be discovered as resulting from their changes. Similar deposits and similar cells were discovered in the spleen.

No collections of pus were found in the lungs, and these deposits differed from collections of pus in that they were firm, could be cut with the scalpel, and the organic corpuscles differed in size and appearance from the pus globule, being somewhat smaller, and having in many cases the marks of development in their caudate and spindle-shaped forms. The dependent portions of the lungs were congested with blood evidently from the effects of gravitation.

Abdominal Cavity. — *Liver.* — Normal in appearance and size. The liver cells under the microscope appeared healthy. The liver cells were, in many cases, of a hexagonal shape, from mutual pressure. The view of Dr. Leidy of the structure of the liver in this case, as well as in numerous others, I found to be erroneous. No delicate system of secreting tubes upon which the liver cells rest could be discovered. The view of Kölliker expresses more nearly the truth. No collection of pus was discovered in any portion of the liver. No pus was observed in the blood of the portal and hepatic vessels, although, as in the case of the blood of the heart, this also contained numerous globules which could not be distinguished from those of pus.

Gall-bladder. — The gall-bladder was distended with thick, tenacious, dark green bile. Plate No. XXXIV.[1] represents the color of the bile. This has been painted with the bile directly from the gall-bladder.

Pancreas. — Normal.

Alimentary Canal; Stomach. — Distended with gas and food. The contents were colored of a deep green from the admixture of bile. Mucous surface pale and healthy.

Intestinal Canal. — Upon the exterior appeared to be healthy. Small intestines distended with gas. The ileum contained much soft fluid fæcal matter, of a deep green color, from the presence of bile. Mucous membrane of small intestines, pale and apparently healthy. Neither Peyer's nor the solitary glands were enlarged or softened. Lymphatic glands of the mesentery not enlarged; firm and normal in appearance and structure. A single large lymphatic gland, about one inch in length, was observed in the right groin, just over the position of the large vessels.

Large Intestine. — Contained healthy-looking, hard, yellow fæces. Mucous membrane pale and healthy. Bowels have been, as a general rule, unaffected throughout this disease. The patient had two rather watery evacuations as recorded, but these appeared to have been induced by the free use of molasses.

[1] Omitted.

Spleen. — Enlarged about four times its natural size. Light yellow, cheese-like deposits were found in this organ, similar to those described in the lungs, and presenting a similar appearance under the microscope. Plates Nos. XXXV. and XXXVI.[1] represent the appearance of the deposits in the spleen, as well as their microscopical structure. These cells were compared with the pus globules from the pus of the femoral vein, and found to differ materially from them in the particulars which we have before given. No collections of pus were discovered in this organ.

Commentary. — 1. The nervous, depressed state in which this patient remained in consequence of an ill-conditioned and gangrenous wound of the calf of the right leg, was attended with elevation of the temperature of the trunk several degrees above the standard of health, marked diurnal variations of temperature, great irritation and feebleness of the general circulation, and imperfect and feeble capillary circulation, as manifested by the marked difference of temperature between the trunk and the extremities, and the inability of the extremities to maintain a definite temperature and withstand the effects of external cold. The periodical elevations and depressions of temperature were intimately associated with the action of the heart. As a general rule, acceleration of the heart's action was attended with an increase of temperature, and decrease in the frequency and force of the heart's action was attended with decrease of temperature. The temperature fell to the lowest point in the mornings, when the action of the heart was slowest. The cause of the periodic increase and decrease of temperature must be sought in the cause which produced the disturbances in the action of the heart, or in the varying amounts of blood circulating through the system in given periods of time. We might conceive that the cause which excited the heart to action, also excited an increased chemical change in the system, or so depressed the force which prevents the waste of tissue that the elements were allowed to enter into more rapid chemical changes than usual; or the relations of the vital nervous and physical forces were so disturbed that instead of the generation of nervous force or electricity, we have the increased development of the physical force heat. Commentary.

As, however, the increase of heat was in this case invariably attended with an increased circulation of the blood which furnished the elements of chemical change, and consequently the conditions for the development of the physical forces; and, farther, as the

[1] Omitted.

increased generation of heat was attended by an increase in the products of the changes of the tissues, as manifested by the increased amounts of urea, phosphoric acid, and extractive matters excreted; it is reasonable to conclude that the elevation of temperature was not due so much to some direct action of the nervous system, or to a disturbance of the relations of the vital nervous and physical forces, as to the more rapid circulation of the elements of chemical change. The question may still be asked whether or not the disturbances in the heart's action be due to the direct action of the nervous system upon this organ? Irregularities in the action of the heart may be due to various causes; as the direct action of poisonous bodies upon this organ, or upon the ganglia of the sympathetic system, or upon the constitution of the blood from which the heart derives its nutrition, or upon the cerebro-spinal system, or in all these modes at once. It is our belief that disturbances in the action of the heart in such cases are due to a number of causes; as the direct action of the gangrenous matter upon the structures of the heart itself, or upon the blood, or upon those portions of the sympathetic and cerebro-spinal nervous systems related to the heart.

2. At the end of three weeks the gangrene appeared to be decreasing in extent and severity, and pus in considerable quantities was discharged from the wound, the surface of which was partially covered by a film of fibrous matter. The calf of the leg still continued swollen and painful, and slow changes of an unfavorable character appeared to be progressing beneath the more healthy covering of the wound. Symptoms of pyæmia manifested themselves, and in the course of a week the case terminated fatally.

Notwithstanding the low, depressed state, accompanied by febrile excitement, induced by the action of the poison of hospital gangrene, the supervention of a new disease and the action of a new poison induced an entirely new train of symptoms.

The pyæmia was characterized by increased nervous depression and irritation, increased derangement in the general and capillary circulation, and increased derangement of the blood.

The increased nervous derangement was attended by a marked increase of phosphoric acid in the urine; and the increased changes of the blood, and especially the destruction of the colored blood corpuscles, was attended with a great increase of the coloring matters of the urine.

It is worthy of observation that in this disease and in malarial fever, in both of which there is a more rapid destruction of the

colored blood corpuscles than in any other class of diseases, chills characterize the diseases, and form the most marked diagnostic symptoms. If such facts do not point out the nature of the cause of malarial fever, they at least sustain the belief that the disease is due to the action of a special poison, and not to mere variations of climate and changes of moisture and temperature.

3. Examinations of the diseased leg revealed the following important facts. The muscles of the calf of the leg surrounding the wound were to a great extent disorganized, being broken down into greenish-yellow pus and greenish, sanious matter. The knee joint was distended with thick, cream-like pus. The veins above the seat of injury, which extended into the disorganized structures, were loaded with thick, cream-like pus. At those points where the smaller veins from healthy parts joined the main trunk of the popliteal and femoral veins, clots had evidently formed which had been attached to the semi-lunar valves, and which arrested for a time the progress of the pus towards the right side of the heart. These clots had been gradually dissolved by the pus, and the coats of the veins were discolored by the products of the disorganized blood. With the exception of this discoloration and softening of the venous coats at the points where the clots had formed, the internal surface of the veins containing the pus presented no marks of inflammation or irritation. The femoral and external iliac veins were distended with thick, greenish-yellow pus. Just at the junction of the external with the internal iliac vein, where branches from healthy structures were received, a firm clot of blood attached to the semi-lunar valves plugged up the vein, and barred the farther progress of the pus towards the heart. When the right auricle of the heart was opened, the blood flowed from the distended vena cava and internal iliac, and the large veins collapsed completely, whilst the external iliac and femoral veins remained distended with the cream-like pus. I dissected the veins of the thigh and leg containing pus, and traced them directly into the disorganized structures surrounding the wound, and found that their coats had been disorganized, and thus they communicated freely with the pus and disintegrated matters.

These facts establish the following conclusions: —

(*a.*) The disease was caused by the direct entrance of unhealthy pus into the circulating system through the eroded walls of the veins.

(*b.*) This unhealthy pus, mingled with gangrenous matter, caused the coagulation of the blood.

(*c.*) Whilst the main streams of pus appeared to have been prevented by the coagula of blood from mingling with the general mass of blood circulating through the system, at the same time small portions of pus appeared to enter the general circulation, and bodies resembling in all respects pus globules were numerous in the cavities of the heart, and in the blood-vessels of the left side of the body.

4. The disease was caused by the direct entrance of unhealthy pus into the circulating system, through the erosions in the walls of the veins.

As the disease progressed, the clots which plugged up the extremities of the veins divided by the ball, or destroyed by the gangrene, were gradually dissolved during that peculiar dissolution of the tissues which succeeded the active stages of the gangrene, and which resembled a slow process of moist disintegration combined with an unhealthy form of suppuration, and thus a free passage was afforded for the direct entrance of the diffluent products of the disintegration and liquefaction of the tissues into the blood. The pus was evidently forced into the veins, not by any vis a tergo, but by atmospheric pressure during the dilatation of the right auricle of the heart and during inspiration.

This case demonstrates clearly that they who affirm that pyæmia can only arise from phlebitis are equally in error with those who assert that the disease does never arise from the direct admission of pus into the blood as pus with its globules, but from the absorption through the walls of the blood-vessels of the serous portion of the pus.

At the same time we are not justified by the facts so clearly demonstrated by this case in asserting that this disease is always the result of the direct entrance of pus into the blood through erosions in the walls of the veins; for there are numerous experiments and pathological observations which appear to show that pyæmia may arise from phlebitis, in which the pus is formed within the capillaries and veins without any erosion of the walls and extraneous introduction, or from the absorption of the serum of the pus by the lymphatics and veins without the direct entrance of the pus globule. Rokitansky even affirms that pyæmia occurs not uncommonly as a primitive affection, the pus being actually formed by and in the blood itself, in consequence of certain changes in the fibrin. This author treats pyæmia as a *crasis* presenting a *local pus production*, and also a *spontaneous primitive pyæmia of the entire blood mass.*

It is difficult to conceive why the mere entrance of healthy pus, or the absorption of its serum into the blood, should derange entirely the actions of the nervous system, increase the chemical changes of the elements of the nervous system and of the blood, destroy the colored blood corpuscles, depress the action of the heart, derange the capillary circulation, induce a depressed, irritative, febrile condition of the whole system, and finally cause death. In every granulating wound we have the formation of pus, and its serum bathes the delicate forming capillaries, and it would be unphilosophical to suppose that a portion of it is not absorbed. Abscesses frequently disappear by absorption, and no disturbance of the general system results. Healthy pus has even been injected into the veins of animals without any serious results; and we are inclined to believe that many of the fatal results recorded in such experiments were due rather to the entrance of small portions of air into the veins along with the pus than to the poisonous action of the pus.

The phenomena in this case, as well as in every other well-marked case of pyæmia, were those of active poisoning. The microscope revealed the presence in the pus of particles of the decomposing structures.

We conceive that the view that the disease is owing to the admixture of pus with the blood, and to the fact that the pus corpuscles, being larger than the colored ones of the blood, are arrested in the minute capillaries, and give rise to secondary abscesses, is entirely inadequate to the explanation of the characteristic phenomena of poisoning. In the first place, it is not correct to reason from experiments upon the effects of injecting particles of mercury and gold and other inorganic substances into the circulation, because the particles are far larger than the pus globule, and wholly different in structure. In the second place, there is not such a difference in the size, structure, and chemical and physical properties of the colorless corpuscle of the blood and lymph, of the exudation corpuscles, and of the pus globule of inflammation, as to render it probable that the mere presence of the latter in the blood should be capable of exciting a dangerous disease, attended with the symptoms of violent poisoning, or of arresting the capillary circulation of the blood, and exciting immediate inflammation and suppuration.

It is more philosophical to conclude from all the facts that pyæmia is due to the action of a special organic poison, generated in the system under certain conditions, and almost uniformly asso-

ciated with, if not developed in, the process of unhealthy suppuration, or of analogous degeneration of tissue.

5. The unhealthy pus and gangrenous matter caused the coagulation of the blood in the veins. The coagula were formed chiefly in those portions of the large vein which received venous branches from healthy structures. It should not be supposed, however, that this coagulation of the blood is the uniform mode of action of pus. Whether or not the blood be coagulated, as well as the subsequent alterations of the coagula, depend upon the constitution of the pus, whether healthy or otherwise, and upon the condition of the blood, and the qualitative and quantitative relations of the fibrinous constituent.

The following experiments performed by Dr. Bennett and Professor Barlow demonstrate conclusively that the mixture of pus and blood in the living animal is not necessarily and uniformly attended with the formation of coagula in the vessels.

Experiment 1. — The saphena vein of an ass was exposed, and a tube introduced confined by a ligature. Fresh and healthy pus was then slowly injected *upwards* towards the heart from a syringe holding an ounce. A slight obstruction was now perceived, and the vein above the ligature could be seen to be somewhat swollen. This swelling, on being felt, was very soft; and on pressing the vein from below upwards, the mixed blood and pus was readily pushed before the finger, when all obstruction to the passage of the pus from the syringe was removed. The syringe was again filled, and another ounce of pus injected, without occasioning any further local effects. The animal was then allowed to get up, and exhibited no change in its normal condition whatever.

Experiment 2. — The same ass was the subject of this experiment a fortnight later, having been perfectly well in the interval. Six inches in the jugular vein in the neck were carefully dissected and exposed, and a minute aperture was then made in the upper end of the exposed vein, and the bent tube of the syringe introduced without a ligature. The coats of the vein were so transparent that the flowing blood could be seen through them. An ounce of fresh and perfectly healthy pus was then slowly injected *downwards* towards the heart, and, owing to the transparency of the vein, the yellow opaque fluid was seen to join the blood, to continue a few moments running side by side with the crimson current, until at length the vein became full of pus. On removing the syringe to obtain a fresh supply, the blood from above could be seen to join the pus, to continue side by side with that fluid, presenting a streaked red and white appearance, without any coagulation, until all the pus was carried forwards and downwards towards the heart, and the vein was again full of blood. Another syringe full of pus was then

injected, which could once more be seen, first, to flow with the blood, then, as its quantity increased, to take the place of the blood, and then, on the syringe being exhausted, to receive blood from above; the two mixing together, and continuing their course without coagulating, until once more the vein contained nothing but blood. The wound was now closed, and the animal allowed to rise, which he did without apparent suffering. He presented no unusual symptoms whatever during the next four days, when he was killed, and the parts carefully dissected. The vein was pervious, presented no thickening, nor cording, nor abscesses, and the external wound was nearly healed.

This experiment appeared to be so decisive, and so clearly opposed to the idea that the contact or mixture of pus and blood necessarily induced coagulation in a living animal, that it was thought unnecessary to repeat it. With regard to the slight coagulability apparently occasioned in the first experiment, it was attributed to injecting contrary to gravity, whereby the mixed pus and blood were allowed to fall backwards and remain stationary, while the ligature prevented any flow of blood from being continued. No such phenomena was observed in the second experiment, where no ligature was employed, and where the effect of gravity was avoided by injecting downwards.

The second experiment was in its nature the same as the seventh and eighth experiments of Dr. Henry Lee, and yet none of the appearances observed by that gentleman resulted. There was no fullness, nor cording of the vein, no acceleration of respiration, or constitutional symptoms; and after death, no coagulation of the blood, no obliteration of the vein, nor local inflammation. What are the circumstances which occasioned this difference, I am not prepared to say; but the positive fact of having introduced the pus on two separate occasions, as recorded in Experiment 2, — of having seen the pus mix with the blood, and the blood with the pus, through the transparent vein, without producing coagulation, — is sufficient to negative the general proposition, that whenever pus is mingled with blood in a living animal, coagulation of the latter fluid is the invariable result.[1]

Allowing due weight to the experiments of Dr. Henry Lee and various other observers, who have demonstrated that pus is capable of coagulating the blood both within and without the vessels of animals, the fact that this is not invariably its action is important in its bearings upon the nature and progress of pyæmia. In many cases the rapidity of the development of the constitutional symptoms will manifestly depend in a great measure upon the extent to which the advance of the pus and poisonous matters is resisted by the formation of clots. If no clots retard its progress, the poison-

[1] *Clinical Lectures on the Principles and Practice of Medicine*, by John Hughes Bennett, M. D., etc. Third Edition, Edinburgh, 1859, pp. 896, 897.

ing of the system will be rapid, and in proportion to the deleterious properties of the matter introduced through the veins and distributed to all parts of the system by the heart. If clots be formed, the rapidity of the development of the constitutional symptoms will depend not merely upon the number and size of the clots, but also upon the rapidity and manner in which they are decomposed and detached by the advancing pus. The detachment of a decomposing clot, and the lodgment of its fragments in various important organs, may in like manner greatly aggravate the disease by causing local congestions and exciting unhealthy suppuration in different organs and tissues. Each one of these secondary abscesses may become in turn sources of contamination. If the amount of pus absorbed be limited, and if the clot be so firm as to resist its advance, we may have a comparatively mild form of the disease, terminating in recovery.

6. Whilst the main streams of pus appeared to have been prevented by the coagula of blood from mingling with the general mass of the blood circulating through the system, at the same time small portions of pus appeared to enter the general circulation, and bodies resembling in all respects pus globules were numerous in the blood contained in the cavities of the heart, and in the blood-vessels of the left side of the body.

We desire to speak with due caution on this point, for it is difficult to decide positively whether or not the colorless globules discovered in the blood in such cases be true pus globules or only forms of the colorless corpuscles always found in healthy blood.

According to the observations of Dr. Sedillot, the pus globules are two or three times larger than those of the blood, their contour is more regular, their granular or nipple-like projections are more distinct, their transparency less, their specific gravity greater, and the tendency they have to adhere to bodies prevents their being carried along in the current, as are the blood globules. The *white globules* of the blood, however, have a certain resemblance to those of pus, but exist in far fewer numbers, and are detected with much greater difficulty. In all doubtful cases this observer made contemporary examinations of healthy blood, and of blood to which pus had been added. In his work on Purulent Infection, or Pyæmia, Dr. Sedillot thus presents the results of his observations, and attempts to explain the discrepancies of authors in respect to the detection of pus in the blood: —

"In almost all our experiments we have examined the blood by the aid of the microscope. Generally we have entirely failed in detecting

the pus globule after a single injection of pus, for the instances in which we or our assistants believed we had recognized such in the left cavities of the heart were very inconclusive.

"The same remark applies in all cases in which the secondary abscesses have only commenced forming in the lungs, the stage of complete softening not yet being attained. But in those cases in which large and numerous collections of pus existed, we always found pus in the blood, at whatever part of the system this has been taken from. . . . . In cases of pyæmia in which the metastatic abscesses were not numerous and matured, we met with no traces of pus in the veins which did not communicate directly with the vessels affected with suppuration. The same remark applies to our experiments on living animals. Whatever quantity of pus was injected into the jugular veins, we detected no traces of it in the femorals. We were obliged to admit, therefore, that the globules of the fluid had become arrested in the parenchyma of organs, and we found them in the tissue of the lungs. This was no longer the case when large metastatic collections had formed, for then the blood of every vessel of the body contained pus. It is on these facts that our diagnosis was based in this case, and we have related another in which we were also enabled to announce during life, from a microscopic inspection of the blood, that the anatomico-pathologic changes of pyæmia, with a large collection of matter, would be found at the post-mortem, — an opinion the exactitude of which was confirmed." [1]

M. Lebert states, as the results of his observations, that, however easy it may be to confound the pus globule with the colorless corpuscle of the blood, by a superficial examination with a low magnifying power, the differences become obvious if a power of from five hundred to eight hundred diameters be employed. According to M. Lebert, the dimensions are different, that of the pus globule varying from $\frac{1}{100}$ to $\frac{1}{80}$ millimeter; that of the white globule, from $\frac{1}{125}$ to $\frac{1}{100}$, a sixth or a fifth smaller. The color of the pus globule is slightly yellowish; that of the white globule, a dead white, without any trace of yellow. The form of the pus globule is spherical, while that of the white one is much more flattened, being at most lenticular, and never spherical. The surface of the pus globule is roughened, compared with the smooth surface of the white globule. A marked difference is generally seen in the nuclei as exhibited in both by means of acetic acid. Those of the pus globules are much larger, varying from $\frac{1}{300}$ to $\frac{1}{200}$ millimeter, and exhibit in their interior a regular, well-defined cavity, while the white globule furnishes scarcely other than very small puniliform nuclei of from $\frac{1}{500}$ to $\frac{1}{100}$ millimeter, rather resembling nucleoli, or fatty granules.

[1] *Brit. and For. Med. Chir. Review*, October, 1849.

Dr. Bennett, on the other hand, affirms that "No difference whatever can be detected between the colorless cells of the blood and those of pus. Their general appearance, size, structure, and behavior on the addition of reagents, are identical; indeed, so much so that in the first case (leucocythæmia) I observed in 1845, I could not resist the conclusion that the blood was crowded with pus cells. It follows that all explanations of purulent infection founded upon the mechanical impaction of these bodies in the minute capillaries must be erroneous. Some of these colorless corpuscles have been observed much larger than ordinary pus corpuscles. In one instance many of them were twice as large; and although this may in some measure be owing to endosmosis of serum, there can be little doubt that they must have exceeded the usual size of pus cells."[1]

7. In attempting to determine the cause and nature of this or of any other case of pyæmia, many complicated questions present themselves for discussion.

Is the disease the result of a peculiar condition of the system and blood (a diathesis), or does it result entirely from the introduction of pus into the blood?

What is the state of the system which favors the production of pyæmia? If pus be the cause of the disease, what is the mechanism of its introduction? Is it introduced directly through erosions in the veins, or through their severed extremities, or is it generated within the veins in circumscribed inflamed portions (phlebitis)? or is it absorbed by the lymphatics, capillaries, and veins? In what manner does the pus induce the grave constitutional symptoms characteristic of the disease? Does it act as pus, or does it act by some one of its individual constituents, as the globules, or the granules, or the pyine, or some constituent of its serum, or by a special poison generated only under certain conditions? If the disease be caused by a special poison, what are its physical and chemical characters, and its relations to the blood and to the nervous and circulatory systems?

8. It may be asked, with almost absolute despair, whether treatment has any effect upon such a case after the establishment of the pyæmic disease?

What drug or combination of drugs could reasonably be expected to arrest the progress of the pus through the open veins into the general circulation? Nothing short of a ligation above the pus, or an amputation, would afford any mechanical obstacle

[1] Page 895.

to the progress of the pus. It may well be questioned whether such measures would have any effect after the manifestation of the constitutional symptoms. Amputation should have been performed in this case before the manifestation of the symptoms of pyæmia, to have afforded any chance of recovery.

Case XLVII. Pyæmia supervening upon hospital gangrene.

Case XLVII. J. V. Carrico. Age, twenty-nine. Height, six feet and one half inch. Weight, one hundred and eighty-six pounds in health. Native of Alabama, Marengo County. Occupation before entering the army, farming. Corporal in Selden's Battery. Wounded at Jonesboro', September 7, 1864. A spent minie-ball struck the anterior surface of the left leg, a little to the right of the median line, and penetrated to the tibia, but did not fracture the bone. The ball fell out of the wound without being extracted. Sent at night to Griffin, and remained in the hospital there eight days, and was then transferred to the Floyd House Hospital in Macon. Remained at this hospital from the 8th to the 20th. Gangrene appeared on the 13th, five days after entering this hospital. On the 20th September, was transferred to the Empire Hospital, Vineville. Under the local action of nitric acid and the constitutional treatment of tincture muriate of iron and sulphate of quinia, the gangrene disappeared in a great measure from the wound, and portions of the denuded muscles of the leg commenced to throw up granulations.

October 3. — The upper portions of the wound appear to be free of gangrene, but it is progressing in the lower portions, in two spots. The largest spot is on the left of the median line, and presents a dark gray, green, and bluish color. The tibia is exposed, and the bone is evidently necrosed along the anterior edge, and the gangrene is also slowly progressing in the neighborhood of the necrosed bone. The granulating portions of the wound secrete thick, greenish pus. Upon this day, I executed the drawing, Plate No. XXXVII.[1] During the execution of this drawing, a considerable amount of thick, greenish pus issued from around the necrosed bone.

Five o'clock P. M. Pulse, 101. Respiration, 26. Temperature of hand, 38° C. (100.4° F.). Temperature of axilla, 41° C. (105.8° F.). Tongue clean and red. Sallow complexion. No appetite. Depressed spirits.

October 4. — Nine o'clock A. M. Pulse, 94. Respiration, 28. Temperature of hand, 35° C. (95° F.). Temperature of axilla, 36.8° C. (98.3° F.). Tongue red and coated. No appetite. Gangrene progressing in wound.

Examination of Urine. — Amount of urine collected during twenty-four hours (October 3, 1 o'clock P. M., to October 4, 1 o'clock P. M.), 1,400 CC. = grains 22,271.42. Deep red color, inclining to pink. Specific gravity, 1,010.5. Clear. No deposit at time of passage.

[1] Omitted.

After standing several days, granular deposit of urates. Strong acid reaction, which remained without change for several days.

ANALYSIS OF URINE, NO. 46.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	22,271.42	
Urea	409.64	17.94
Uric acid	5.60	0.25
Free acid	32.34	1.45
Phosphoric acid	36.22	1.62
Equivalent of phosphorus in phosphoric acid	15.92	0.71
Sulphuric acid	22.60	1.01
Equivalent of sulphur in sulphuric acid	8.94	0.401
Chloride of sodium	25.87	1.11
Equivalent of chlorine in chloride of sodium	16.67	0.74

Five o'clock P. M. Pulse, 108. Respiration, 26. Temperature of hand, 39° C. (102.2° F.). Temperature of axilla, 40.2° C. (104.4° F.).

October 5. — Gangrene progressing in the parts of the wound before described. Had a chill this morning. Sallow, anæmic, jaundiced complexion. Wild, nervous expression of eyes. Great nervous and muscular prostration. Pulse 106, and feeble. Voice tremulous and feeble. Tongue dry and red, and slightly coated with light-colored fur at the sides. Great thirst. No appetite. Bowels loose. This case has evidently become one of pyæmia, which has been engrafted upon the hospital gangrene. The supervention of pyæmia does not appear to have altered the progress of the hospital gangrene. The chill was followed by a profuse clammy sweat.

October 6. — Nine o'clock A. M. Pulse, 110. Respiration, 28. Tongue dry and coated. Patient nervous and restless, and has a wild expression of the eyes, and has had several chills during the last twenty-four hours. His mind does not appear to be altogether clear; sometimes wanders. His countenance is expressive of an undefined dread and horror. The eye-balls have a restless movement. Temperature of hand, 38° C. (100.9° F.). Temperature of axilla, 39° C. (102.2° F.).

Six o'clock P. M. Pulse, 95. Respiration, 26. Temperature of hand, 40.5° C. (104.9° F.). Temperature of axilla, 41° C. (105.8° F.). Delirious, with a wild expression of countenance. It was necessary to tie the patient in bed, on account of his violent delirium. Jaundiced complexion. No appetite. Chills continue. Tongue dry and coated.

October 7. — Nine o'clock A. M. No change for the better.

Six o'clock P. M. Appears a little more rational. Tongue more moist. Pulse, 95.

October 8. — Nine o'clock A. M. Rational. Tongue dry. Pulse weak and frequent, 128. Vomiting of green matter.

Six o'clock P. M. No change.

October 9. — Nine o'clock A. M. Continues to grow worse. Vomiting of green matter still troublesome. Skin and eyes decidedly jaundiced.

Six o'clock P. M. Pulse very feeble. Patient sinking. Vomiting of green bile still continues and did not cease up to the time of death, which occurred at nine o'clock P. M. Patient rational at the time of death. By my request, Assistant-Surgeon Powell, in charge of Ward No. 1, Empire Hospital, examined the diseased leg after death, with the following results: —

Accumulation of pus within the knee joint. Veins below the knee greatly engorged with a thin fluid containing pus. The popliteal veins contained pus and clots of blood. The femoral vein above the popliteal space contained numerous clots of blood, but no pus evident to the eye. The upper portion of the femoral vein, towards the trunk, contained fluid blood. It was impossible for me to be present at this post-mortem, and no further examination was made.

Commentary. — This case presents several points in common with the preceding one.[1] The disease appeared to be due to the entrance of unhealthy pus through the erosions in the veins. It is probable, also, that much pus may have entered through the veins distributed through the denuded and dead bones. The arrangement of the veins through bony structures is such as readily to admit of purulent absorption when the bone becomes infiltrated with unhealthy pus, and especially when that pus possesses corrosive qualities. Commentary.

CASE XLVIII. W. F. Cloar, Company A, 33d Regiment, Tennessee Vols., Sthall's Brigade, Cheatham's Division. Native of Western Tennessee, near the Kentucky line. Age, twenty-four years. Brown hair; brown eyes. Florid complexion. Height, six feet. Weight in health, one hundred and eighty pounds. Strong, athletic man. Had never been sick in his life until after the battle of Shiloh. Has been in Confederate service three years. Was wounded at the battle of Shiloh; ball passed through lower portion of gastrocnemius muscle. This healed rapidly in the course of two weeks. Case XLVIII. Pyæmia supervening upon hospital gangrene.

At the battle of Jonesboro', 30th of August, 1864, a minie-ball passed entirely through the right leg, and fractured the tibia, and scraped the skin off the anterior surface of the left leg, just over the tibia. Right leg amputated on the field of battle, near the junction of upper with middle third. The wound of the left leg appeared to be very slight, and the bones were uninjured. On the next day, the patient was removed from the battle-field to Griffin, Georgia. Remained there

[1] Case XLVI.

three weeks, and was then transferred to the Empire Hospital, Vineville. Gangrene appeared in the wounds (stump left leg and wound left leg) one week before leaving Griffin. Suffered with keen pains in the wounds at the time of the appearance of the gangrene. Entered the Empire Hospital 21st of September.

The local application of nitric acid appeared to arrest the gangrene in a measure.

October 1. — Stump of right leg still much swollen and gangrenous over a portion of the surface. Some portions, however, are more healthy in appearance, and discharge a fetid, thick, green pus, which adheres with some tenacity. Bones exposed and protruding. The whole stump has an ill-conditioned, pale, flabby look. The odor is intolerable. The diseased surface is highly sensitive; the patient cries out whenever it is dressed, or even touched. On the left leg the wound is four inches in length, and three and one half inches in breadth, and exposes the anterior surface of the tibia, which is evidently necrosed. The gangrene appears to be pretty well removed from this wound, which nevertheless presents a pale, flabby look, and discharges fetid pus.

Twelve o'clock M. Pulse, 100. Respiration, 20. Temperature of hand, 39° C. (102.2° F.). Temperature of axilla, 39.2° C. (102.6° F.).

October 2. — Pulse, 120. Respiration, 30. This morning, at nine A. M., the pulse was 95, and respiration 28. Hectic flush on cheek. Patient nervous; very weak. Appetite poor. Pulse feeble. Temperature of hand, 37.2° C. (99° F.). Temperature of axilla, 38° C. (100.4° F.). Surface of stump very sensitive. Patient screams out whenever it is dressed.

Examination of Urine. — Amount of urine collected during twenty-four hours, October 1, 12 M., to October 2, 12 M., 860 CC. = grains, 13,864.96. Deep brownish-red color. Specific gravity, 1,024. Reaction strongly acid, and continued so at the end of four days, with little change. Deposit of deep red crystals of uric acid of the lozenge shape. Also numerous nucleated vegetable cells, apparently of some plant in process of rapid generation. At this time, when the weather was warm and moist, this plant was found in all the specimens of urine collected in the Empire Hospital.

October 2. — Nervous and restless. Although a brave man and a good soldier, screams out and cries like a child whenever his stump is touched.

Nine o'clock A. M. Has been vomiting, and has no appetite. Complains of constriction across his chest. Pulse, 100. Respiration, 24. Temperature of hand, 38.4° C. (101.1° F.). Temperature of axilla, 38.5° C. (101.3° F.). Stump continues much in the same condition, — pale, flabby, with gangrenous sloughs in certain portions, and the large portion of the surface discharging much fetid, greenish pus. Hectic flush upon cheeks; great nervous prostration.

The drawing (Plate No. XXXVIII.[1]) represents the appearance of the wound of the left leg.

Five o'clock P. M. Pulse, 104. Respiration, 28. Tongue rather dry, but not coated, and redder than normal. Patient appears drowsy. Hectic flush on cheeks more distinct towards the close of the day. Bowels costive; took a purgative last night. Temperature of hand, 39° C. (102.2° F.). Temperature of axilla, 40.1° C. (104.2° F.). The treatment has been tincture of sesquichloride of iron, gtts. xv.; sulphate of quinia, grs. v., three times a day; elixir of vitriol (dilute aromatic sulphuric acid), gtts. xxx., three times a day; whiskey, f℥i., every four hours. Diet, eggs and chickens. This is still continued.

ANALYSIS OF URINE, NO. 47.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours	13,864.96	
Urea	682.06	49.12
Uric acid	10.32	0.74
Free acid	38.40	2.77
Phosphoric acid	68.86	4.96
Equivalent of phosphorus in phosphoric acid	30.29	2.26
Sulphuric acid	49.80	3.59
Equivalent of sulphur in sulphuric acid	19.92	1.45
Chloride of sodium	13.24	0.95
Equivalent of chlorine in chloride of sodium	8.02	0.51

October 4. — Ten o'clock A. M. Respiration, 28. Pulse 122, weak. Temperature of hand, 35.5° C. (95.9° F.). Temperature of axilla, 40.2° C. (104.4° F.). Tongue dry, and coated with yellow fur. No improvement of symptoms. Continue treatment.

Six o'clock P. M. Pulse 116, somewhat stronger than this morning. Bright hectic flush upon cheek. Patient restless and nervous. Dozes frequently; and although rational when aroused, appears to be sluggish. Complexion is assuming a very sallow hue. Respiration, 30. Temperature of hand, 38° C. (100.4° F.). Temperature of axilla, 40.8° C. (105.5° F.). Continue treatment.

October 5. — Ten o'clock A. M. Jaundiced hue. Has had a chill. Symptoms of pyæmia well marked. Pulse 102, weak. Respiration, 24. Tongue dry and coated. Temperature of hand, 37.5° C. (99.5° F.). Temperature of axilla, 38° C. (100.4° F.).

Four and one half o'clock P. M. Respiration, 26. Pulse 122, fuller than in the morning. Temperature of hand, 38° C. (100.4° F.). Temperature of axilla, 40.4° C. (104.7° F.). Tongue coated and dry. Some erysipelatous inflammation of left leg in region of wound. Gangrene progressing slowly along a small portion of the border of this wound, which

[1] Omitted.

presents a pale, flabby appearance, and discharges, as in the case of the stump, fetid pus. The patient is inclined to doze frequently.

Examination of Urine. — Amount of urine collected during the past twenty-four hours, 900 CC. = grains 14,488.82. Deep pinkish-red color. The color resembles that of the urine of Parker, and appears to be characteristic of pyæmia. Specific gravity, 1,022.5. Clear; no deposit after collection. Strong acid reaction, which continued for several days. This afternoon had a hemorrhage from the stump. This appeared to exhaust the patient considerably.

ANALYSIS OF URINE, NO. 48.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours.	14,488.82	
Urea	693.00	47.83
Uric acid	14.40	0.099
Free acid	48.51	3.34
Phosphoric acid	72.07	4.98
Equivalent of phosphorus in phosphoric acid	31.70	2.18
Sulphuric acid	40.25	2.77
Equivalent of sulphur in sulphuric acid	16.10	1.118
Chloride of sodium	41.58	2.87
Equivalent of chlorine in chloride of sodium	25.19	1.73

October 6. — Nine A. M. Pulse, 110. Respiration, 28. Temperature of hand, 36.3° C. (97.4° F.). Temperature of axilla, 38° C. (100.4° F.). Tongue coated. Patient restless, nervous, and feeble. Has had several chills. The hemorrhage has still further reduced his feeble forces.

Examination of Urine. — Amount of urine collected during twenty-four hours, October 5, 5 P. M., to October 6, 5 P. M., 580 CC. = 9,376.51. Specific gravity, 1,027. Pinkish-red color. The color of the urine has diminished somewhat in intensity since the occurrence of the hemorrhage.

ANALYSIS OF URINE, NO. 49.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours.	9,376.51	
Urea	462.67	49.34
Uric acid	9.04	0.96
Free acid (thirty-six hours after collection)	35.72	3.809
Phosphoric acid	53.59	5.71
Equivalent of phosphorus in phosphoric acid	23.57	2.51
Sulphuric acid	29.20	3.11
Equivalent of sulphur in sulphuric acid	11.68	1.24
Chloride of sodium (slight trace)	Slight trace	
Equivalent of chlorine in chloride of sodium	Slight trace	

It is probable that this was not the entire amount of urine, as the patient's bowels have been running off, and he has been vomiting green bile, and can retain nothing upon his stomach.

Six o'clock P. M. Pulse, 120. Respiration, 28. Tongue coated. Vomiting of green bile continues. Patient depressed and feeble. Temperature of hand, 39.2° C. (102.6° F.). Temperature of axilla, 40° C. (104° F.).

October 7. — Nine A. M. Temperature of axilla, 39° C. (102.2° F.). Temperature of hand, 38° C. (100.4° F.). Pulse, 115. Respiration, 26. Tongue coated. Vomiting has ceased.

Six o'clock P. M. Pulse, 110. Respiration, 28. Tongue red and coated. Temperature of hand, 40.4° C. (104.7° F.). Temperature of axilla, 41° C. (105.8° F.).

October 8. — Nine A. M. Pulse frequent and feeble. Tongue red. No appetite. Patient very feeble. Eyes and skin of a decided jaundiced appearance. Chills, or chilly feelings, still continue at varying periods.

Six o'clock P. M. Continues much in the same condition.

October 9. — Nine o'clock A. M. No improvement.

October 10. — Green vomit. Very feeble and rapid pulse; difficulty of breathing.

October 11. — Nine o'clock A. M. Vomiting continually. Pulse weak and frequent.

Six o'clock P. M. Patient sinking.

October 12. — Died at eleven o'clock A. M. Appeared to be rational up to the moment of death.

Commentary. — The urine presented the same pinkish-red color and a similar chemical constitution with the urine of Parker. These observations show that the poison inducing pyæmia acts according to fixed laws, and induces determinate changes in the nutrition, secretions, and excretions.

The two following cases were examined and reported at my request, by Assistant-Surgeon Anderson, of the Ocmulgee Hospital, Macon, Ga.: —

Case XLIX. Pyæmia supervening upon hospital gangrene.

CASE XLIX. Samuel L. Dukoy, private, Company D, 15th Texas Regiment. Age, twenty-four. Occupation before entering service, farming. Nervo-lymphatic temperament. Entered Ocmulgee Hospital, Ward No. 8, September 24, with resection of about four inches of middle third of left tibia, result of compound fracture caused by gunshot wound. The patient had erysipelas ten days previous to his entrance into this hospital. At the time of his admission the erysipelas had been arrested; the wound, however, was affected with hospital gangrene, the extent of the diseased parts being about four by six inches, and involving

seriously the tibialis anticus muscle. The gangrenous tissues presented a greenish color, and protruded beyond the surface. Unconnected with the large ulcer, and apparently in the same structures, there were two ulcers, from eight to twelve lines in diameter, respectively, resembling very nearly superficial effusions of pus. Pulse 140, and feeble. Patient delirious in the evening and fore part of the night. The leg was treated with double inclined plane to support it, and nitric acid was applied daily. The free administration of sulphate of quinia and whiskey in the fore part of the day relieved the delirium. By his own request he was transferred to Ward 7, saying that he desired not to be exposed to the suffering of so many wounded. He became very cheerful, appeared to improve very much in every respect, except that there was rapid emaciation. On the 26th of October he was attacked with very marked nervous prostration, and loss of appetite, and he began to eructate a dark greenish and offensive matter. This vomiting could not be controlled, and he died on the 29th of October.

An examination after death revealed the following condition of the diseased parts. The tibialis anticus, which was so seriously invaded when he was admitted, appeared to be almost perfectly restored in continuity, but was of a dark-purple color. Diffusive infiltration of pus in all the structures surrounding the wound. The sheath of the anterior tibial artery contained pus in the upper part. The anterior tibial nerve presented a bulbous or ganglionic termination in the upper edge of the diseased parts, its continuity having been destroyed by some means, probably at the time of the injury or at the time of the amputation, or by the disease. The anterior tibial artery could not be isolated in the vicinity of the diseased parts; it appeared to terminate in a tuft of muscular or very minute vascular structure. The veins above the diseased parts resembled arteries in appearance, the coats being thick and indurated, containing numerous clots of disintegrated fibrin — fibrinous clots — apparently undergoing a process of softening. The superficial vein that passes over the anterior aspect of the interior malleolus, could not be isolated in the vicinity of the wound, and contained a continuous clot of oxidized or scarlet blood. This was likely due to a lack of coloring material in the blood mass. I do not think that hospital gangrene was the immediate cause of death in this case, for the disease was on the decline, and had been for several days. He appeared to die as cases do of pyæmia; rigors, nervous prostration, and vomiting of offensive, dark greenish matter, were the precursors of death.

Case L. Pyæmia supervening upon hospital gangrene.

CASE L. J. W. Street, 66th Georgia Regiment, Company C. Age, forty-seven. Profession, farming, before entering service. Was admitted into Ward No. 10, October 2, with compound fracture of left ankle joint, caused by gunshot wound, received August 31. On the 20th of October I was present

when his leg was amputated by Assistant-Surgeon P. H. Wright. The limb was removed by circular operation immediately above the ankle joint. I took occasion to examine carefully the joint. Upon cutting into it, a large quantity of very offensive pus escaped. There was no appearance of the disease "hospital gangrene" in this wound. The astragalus was completely comminuted, the os calcis also badly fractured. The health of the patient had been rather bad; had suffered for some time with passive dysentery.

About the 24th of October I saw him again. Pulse, 140 to 150, and feeble. Stump dry, and of an ashy or gray color. On external side of his leg, from the knee down, there was an extensive sero-sanguineous effusion, one of the marked signs of dissolution. Died, October 28. The symptoms preceding death were rigors and nervous depression.

Careful dissection of the diseased parts revealed extensive infiltration of pus. The anterior tibial artery contained dark, uncoagulated blood. The veins contained numerous dark, softened or apparently decomposed fibrinous clots. Bones necrosed to the extent of about one inch. The coats of the veins in this case were very nearly normal. The corrugated or inflammatory appearance was removed by careful washing.

We will in the next place consider briefly whether pyæmia is more common in cases of hospital gangrene than in those cases in which the wounds present the appearance of ordinary suppurative inflammation. Unfortunately the data for the settlement of these questions are in a great measure wanting.

Numerical relations of pyæmia and hospital gangrene in Army of Tennessee, July and August, 1864.

The following table presents the numerical relations of pyæmia and hospital gangrene, and several other diseases, during a short period of time in the general hospitals attached to the Army of Tennessee: —

SICK AND WOUNDED IN HOSPITALS, ARMY OF TENNESSEE, FOR MONTHS OF JULY AND AUGUST, 1864.

Diseases.	July, 1864.				August, 1864.				Total.	
	Original Ad.		Re-ad.		Original Ad.		Re-ad.			
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Febris cont. simplex	158	8	8	5	158	4	2	–	326	17
Febris typhoides	185	67	49	23	110	43	29	14	373	147
Febris typhus	–	–	–	–	–	–	–	–	–	–
Rubeola	661	33	44	8	654	11	47	6	1,406	58
Variola	1	–	–	–	3	–	–	–	4	–
Varioloides	–	–	–	–	–	–	–	–	–	–
Scarlatina simplex	–	–	–	–	–	–	–	–	–	–
Scarlatina anginosa	–	–	–	–	–	–	–	–	–	–
Scarlatina maligna	–	–	–	–	–	–	–	–	–	–
Parotitis	62	1	–	–	54	–	–	–	116	1
Diphtheria	3	–	–	–	3	–	–	–	6	–
Erysipelas	–	–	–	–	–	–	–	–	–	–
Erysipelas idiopathic	56	–	4	–	37	–	5	–	102	–
Febris interm. quotid	606	1	2	–	402	3	10	1	1,020	5
Febris interm. tertiana	546	1	5	–	596	1	14	–	1,161	2
Febris interm. quartana	25	–	–	–	21	–	–	–	46	–
Febris congestiva	4	3	1	–	9	3	9	3	23	9
Febris remit. biliosa	1,273	14	7	–	1,272	29	15	8	2,567	51
Diarrhœa acuta	1,887	6	14	–	1,714	6	22	1	3,637	13
Diarrhœa chronica	2,590	72	2	1	2,122	56	2	2	4,716	131
Dysenteria acuta	–	–	–	–	–	–	–	–	–	–
Dysenteria chronica	–	–	–	–	–	–	–	–	–	–
Colitis acuta	573	21	16	1	292	21	7	2	888	45
Colitis chronica	89	5	–	–	205	6	1	–	295	11
Hepatitis acuta	55	–	–	–	51	–	1	1	107	1
Hepatitis chronica	70	–	–	–	98	–	–	–	168	–
Bronchitis acuta	81	–	–	–	95	–	4	–	180	–
Bronchitis chronica	79	–	–	–	65	–	–	–	144	–
Catarrhus epidemicus	1	–	–	–	2	–	–	–	3	–
Catarrhus	78	–	–	–	40	–	–	–	118	–
Pleuritis	55	2	–	–	82	–	–	–	137	2
Pneumonia	203	30	22	5	220	7	20	2	465	44
Pneumonia typhoides	13	1	–	–	3	1	–	–	16	2
Gangræna sicca	2	–	7	–	11	–	4	–	24	–
Gangræna humida	5	–	41	5	45	4	79	2	170	11
Phagedæna gangrænosa	21	1	147	2	230	9	256	3	654	15
Pyæmia	–	2	25	23	8	7	72	70	105	102
Contusio	394	2	1	–	184	2	3	–	582	4
Vulnus incisum	22	–	–	–	18	–	–	–	40	–
Vulnus cont. vel laceratum	–	–	–	–	–	–	–	–	–	–
Vulnus laceratum	22	–	–	–	20	–	–	–	42	–
Vulnus punctum	3	1	–	–	4	–	–	–	7	1
Vulnus punctum sclopeticum	9,269	416	5	–	7,961	409	25	2	17,260	827
Erysipelas traum.	21	1	22	–	8	–	19	–	70	1
Luxatio simplex	11	–	–	–	9	–	–	–	20	–
Luxatio composita	3	–	–	–	2	–	–	–	5	–
Fractura	–	–	–	–	–	–	–	–	–	–
Fractura simplex	20	–	–	–	17	–	1	1	38	1
Fractura composita	19	2	–	–	56	–	–	–	75	2
Sub-luxatio	12	–	–	–	16	–	–	–	28	–
Concussio cerebri	7	–	–	–	10	–	–	–	17	–
Compressio	–	–	1	1	–	–	–	–	1	1
Suicidium	–	–	–	–	–	–	–	–	–	–
By hanging	–	–	–	–	–	–	–	–	–	–
By drowning	–	–	–	–	–	–	–	–	–	–
Irrespirable air	–	–	–	–	–	–	–	–	–	–
Military execution	–	–	–	–	–	–	–	–	–	–
Total of all other diseases	4,551	18	225	25	4,341	25	53	18	9,170	81
Total all diseases	23,736	708	648	99	21,248	647	700	131	46382	1,585

We observe from this table, that during the month of July, 9,274 cases of gunshot wounds were treated, with 416 deaths;

214 cases of hospital gangrene (gangræna humida and phagedæna gangrænosa), 8 deaths; 25 cases of pyæmia treated, with 25 deaths. During the month of August, 7,986 cases of gunshot wounds were treated, with 411 deaths; 610 cases of hospital gangrene (gangræna humida and phagedæna gangrænosa), with 18 deaths; pyæmia, 80 cases and 77 deaths.

It is evident, therefore, that notwithstanding a larger number of wounded were received into the general hospitals of the Army of Tennessee in the month of July than in August, the cases of pyæmia were threefold more numerous in the latter than in the former month; and at the same time, the cases of hospital gangrene were very nearly three times as numerous in the month of August. It is fair to infer that because a certain proportion of the cases of hospital gangrene will uniformly terminate in pyæmia, therefore the increase of pyæmia was directly due to a great extent to the increase of hospital gangrene. We cannot suppose that the hygiene of the hospitals had undergone so great a change in the course of one month as to account for this increased mortality, neither can it be referred entirely to climatic causes.

That the hygienic condition of the hospital and climatic conditions had much to do with the production of pyæmia, independently of any preceding gangrene, we do not deny; and that this disease ofttimes arose from the action of causes limited to individual hospitals, is evident from the fact that the mortality for pyæmia was greater in some hospitals than others, and the reports of such hospitals do not show any unusual amount of hospital gangrene.

I have carefully examined the monthly reports of all the general hospitals attached to the Army of Tennessee, for the months of July and August, in order to ascertain whether any observations had been made by the surgeons in charge to account for the origin and increase of pyæmia and hospital gangrene.

These months were especially interesting, from the active operations of the siege of Atlanta, and the bloody battles preceding its evacuation by the Confederate forces.

No observations of any consequence appear in the reports for July. The following are the only observations of any note bearing upon the origin and spread of pyæmia and hospital gangrene: —

Foard Hospital, Forsyth, Georgia; Monthly Report for 1864. — By

Cases of pyæmia treated in Foard Hospital, Forsyth, Ga., Aug., 1864.

reference to the accompanying report, it will be found that eighteen cases and eighteen deaths of pyæmia are recorded as having occurred in the hospital during the month of August.

We are at a loss what to ascribe as the cause of so many cases of this unfortunate sequence in the history of the treatment of gunshot wounds in this hospital. Were it not that the mysterious cause, whatever it is, has, we understand, affected the wounded in other hospitals on the line of the Macon and Western Railroad, to a greater or less degree, we might be led to believe that the surprisingly large number of cases in our establishment might be charged to some purely local cause, or surgical mismanagement on our part.

The post of Forsyth is situated on the Macon and Western Railroad about seventy-five miles from Atlanta, and twenty-five miles from Macon, Georgia, on high, dry, and apparently healthy ground. The Ocmulgee River is eleven miles distant in an eastern direction. This stream has low banks, and is subject to occasional overflow. The plentiful existence of mosquitoes at this point has influenced the belief in my mind that there might be malarial influences at work among our wounded, as all the cases of pyæmia herewith recorded have been ushered in by chills or rigors, and scores of others have had chills or rigors during the month of August, among our wounded, time and again, in whom no unpleasant symptoms have supervened beyond the ordinary stages of intermittent fever, and these were easily cured by quinine. The people who live in and around Forsyth, do not seem to be affected by malarial influences. Citizens consider this a remarkably healthy location; the water is very good, and there seems to be no local cause of disease immediately around our camp.

During the month of August, we had a great deal of wet and sultry weather in this locality, and it was during this time that the cases of pyæmia were most prevalent.

When the order was issued last spring to open our camp hospital, we congratulated ourselves that in tents, with plenty of pure air and generous diet, pyæmia, erysipelas, and hospital gangrene, or phagedæna, would be but of rare occurrence.

The change from houses to tents, I regret to say, has not answered my fondly cherished expectations, though the season of the trial of the latter has been unpropitious.

(Signed) J. W. SINGLETON,
Surgeon in charge pro tem.

Cases of pyæmia occurring in Quintard Hospital, Griffin, Ga., Aug., 1864.

Quintard Hospital, Griffin, Georgia, August, 1864. — Five cases marked "died from vulnus sclopet.," were carried off with pyæmia. Two were very extensive flesh-wounds of the arms and shoulder; one, amputation of upper third of arm; one, resection of upper half of both bones of fore-arm, and the had five wounds, four of the flesh, and the fifth a compound frac-

ture of the acromion. These cases all occurred in one ward, the best ventilated, neatest, and least crowded in the hospital. The patient who first had it, presented symptoms of the disease when he came in; was very weak and anæmic; pulse quick and small; countenance anxious, etc. He sank in a few days with rigors, pains, swelling of ankles, etc. The other four cases occurred immediately after the termination of the first. All of these had severe rigors every day, violent pain in their limbs, and three had well-marked purulent deposits in the lungs. Only one was jaundiced. Two died in a week; one in three weeks; one in ten days; and the last in four days. Large doses of sulphate of quinia, generous diet, stimulants, and opiates were employed. All the wounded were immediately taken out of the room, and it was thoroughly aired, scoured, and whitewashed. These are all the cases that have ever occurred in this hospital.

(Signed) S. V. D. HILL,
Surgeon in charge.

In the Quintard Hospital, fifteen cases of phagedæna were reported as supervening during August.

Hospital gangrene and pyæmia in Gilmer Hospital, August, 1864.

Gilmer Hospital, Forsyth, Georgia, August, 1864. — The number of cases of pyæmia and phagedæna have been unusually large in proportion to the number of cases treated; more than have ever occurred in my experience in C. S. A. hospital practice, now two years. I attribute it, without doubt, to the fact that this hospital is in tents, and the consequent inability of protecting the patients from the noxious influence of the dampness which prevailed during the first part of the month of August. Will this condition of things recur with a similar state of the atmosphere? I have every reason to believe in the affirmative.

(Signed) CHARLES E. MICHEL,
Surgeon in charge.

In the Gilmer Hospital, during the month of August, thirty-four cases of phagedæna gangrænosa, and ten cases of pyæmia, and nine deaths from this last disease, were reported.

Hospital gangrene and pyæmia in Reid Hospital, August, 1864

Reid Hospital, West Point, Georgia, August, 1864. — During the month of August, there were 1,039 received in hospital. Of this number, 586 were treated as patients. The 14 supervening cases added, equal 600 cases treated. Ninety-nine were furloughed. There were 46 wayside accommodations. . . . . Only three cases of erysipelas originated in the hospital during the month. There were five cases of pyæmia (supervening); every case proved fatal within five days. There were six cases only of phagedæna gangrænosa (supervening); only one case proved fatal.

Darby's prophylactic fluid, tar poultices, nitric acid, and the acid

nitrate of mercury, were the remedies used in the treatment of this disease. The acid nitrate of mercury, in my humble opinion, is almost a specific in the treatment of gangrene.

℞. Red oxide of mercury, ʒi.; nitric acid (pure), fʒi. Mix. To be applied in the proportion of one ounce of water to one dram of the mixture. To be increased in strength as the urgency of the case may require. It may be used without dilution.

The above formulary is the original, as I obtained it from the Prussian pharmacopœia. If the profession would use this remedy in the treatment of gunshot wounds, I am of the opinion that gangrene would be robbed of its terrors. . . . .

(Signed) J. W. OSLIN,
Surgeon in charge.

The subject of the origin and relations of hospital gangrene and pyæmia will be more fully discussed hereafter, under the head of the Causes of Hospital Gangrene, and the relations of various diseases.

The next cause of death in hospital gangrene, which we will notice briefly, is —

11. *Phlebitis.*

11. Phlebitis as a cause of death in hospital gangrene.

This disease is intimately associated with pyæmia in many cases.

That gangrene excites inflammation and fibrinous deposition in the veins within and around the diseased parts, we have demonstrated by post-mortem examinations. Nature appears to adopt the fibrinous occlusion of veins in gangrenous masses as the most efficient means of guarding against hemorrhage, and the entrance of air, and the poisonous gangrenous matters, into the circulation.

The coagulated blood contained in the veins, passing within and around gangrenous tissues, may undergo decomposition, and poison the general mass of the blood; or, becoming detached, it may be transported to various parts of the circulatory apparatus, and cause obstruction in important vessels, and stagnation of blood, and inflammation of vital organs.

Some cases of sudden swelling of limbs during the progress of hospital gangrene are best accounted for by the plugging up of the main venous trunks by coagula.

The last causes of death in hospital gangrene, which we will notice, are —

12. *Various results or sequelæ of the local and constitutional*

effects of hospital gangrene, as profuse and unhealthy suppuration from large granulating surfaces; necrosed bones, causing irritation, and keeping up suppuration and hectic fever; permanent impairment and debility of the digestive organs.

12. Various other causes of death in hospital gangrene.

After the patient has passed through a long and tedious attack of hospital gangrene, he may finally fall a victim to any one or all of the causes combined which we have just enumerated. It will be unnecessary for us to dwell upon these causes of death, for the states of system induced by these causes and accidents, do not differ from those following ordinary wounds which have never been gangrenous.

CHAPTER FIFTH.

CAUSES OF HOSPITAL GANGRENE.

Causes of Hospital Gangrene. — 1. A Debilitated and Cachectic State of the Constitution. — Such Derangement of the Solids and Fluids as favor the Production of Hospital Gangrene, may be the Result of Exposure, Fatigue, Bad Diet, and Impure Water, and also of the Rapid and Slow Action of a Special Poison in a Low, Humid, and Miasmatic Atmosphere. — Illustrative Observations, by Various Observers. — Effects of Climate and Malaria in predisposing to Ulcers and Hospital Gangrene. — Effects of the Climate of the West Indies upon the Health of English Troops. — 2. The Air of Crowded Hospitals, Tents, and Ships, loaded with Animal Exhalations. — Hospital Gangrene may at any time arise *de novo*, when Sick and Wounded Soldiers are crowded together in Badly Ventilated Houses, Filthy Hospitals, Close Box Cars, or on Shipboard. — Hospital Gangrene will arise most readily under these Circumstances, when the Soldiers have been on Scanty and Poor Food, and have been exposed to Fatigue, Loss of Rest, the Constant Excitements of Battle, and the Unhealthy Atmosphere of Crowded, Filthy Camps, and Beleaguered Cities. — Illustrative Observations. — 3. The Contact of the Gangrenous Matter with Diseased and Wounded Surfaces, as in using Unclean Sponges, Bandages, Wash-bowls, and Surgical Instruments. — Illustrative Observations. — Origin and History of Hospital Gangrene amongst the Federal Prisoners confined in Camp Sumter, Andersonville, Georgia.

1. *A debilitated and cachectic state of the constitution.*

1. Cause of hospital gangrene. Such derangements of the solids and fluids as favor the production of hospital gangrene, may be the result of exposure, fatigue, bad diet, impure water, and malaria.

Such derangements of the solids and fluids as favor the production of hospital gangrene, may be the result of exposure, fatigue, bad diet, and impure water, and also of the rapid and slow action of a special poison in a low, humid, and miasmatic atmosphere.

If the doctrine advanced by John Hunter — that a certain degree of vital tone or energy is requisite for the formation of coagulable lymph, by which the spreading of inflammation and sphacelation will be prevented, and that where, owing to deficiency of vital energy, vascular action is incompetent to the formation of coagulable lymph, these lesions will extend, and the morbid fluids will contaminate the surrounding tissues — be accepted as an axiom in pathology, and be enlarged so as to embrace the doctrine that the character and progress of inflammations will depend also upon the physical and chemical constitution of the solids and fluids, we will have gained something towards the explanation of the fact, that hospital gangrene, which was almost unknown as an American disease previous to the present war, has, at least in the Confederate armies,

progressively increased in amount and severity. An insufficient supply of food, as well as the prolonged and too exclusive use of salt food, not only impair the efficiency of soldiers, by rendering them less capable of enduring exposure and fatigue, and by inducing that cachectic state of the system which is favorable to the development of diarrhœa and scurvy, but also render the accidents of battle more fatal, by the unfortunate progress of inflammation in gunshot wounds. In the earliest periods of the present war, the Confederate armies were composed in large measure of men who had been accustomed to an abundant and varied diet, a large portion of which consisted of animal food. Notwithstanding the unavoidable crowding of the hospitals, and the existence of all the circumstances most favorable to the development and spread of hospital gangrene in the first months of the war, this disease appears to have been almost unknown, until a change had been wrought in the constitution of the soldiers by fatigue, exposure, and reduced rations, from which both coffee and vegetables were almost universally absent.

Changes induced in the human system by malaria favorable to the origin and spread of hospital gangrene.

A low, moist, stagnant, malarious atmosphere is not only in itself favorable to the origin and spread of hospital gangrene, but it also induces in troops serving in low, malarious regions, changes in the solids and fluids unfavorable to sthenic inflammation. Thus, as I have shown by previous investigations,[1] the malarial poison induces profound alterations in the constitution of the blood. Under its action the colored blood corpuscles are more rapidly and to a greater extent destroyed than in any other disease, with the exception, perhaps, of pyæmia. The fibrin is diminished, and also altered in quantity. The albumen is in like manner diminished. The extractive and coloring matters of the blood are frequently increased. During the active stages of malarial fever, phosphorus and the compounds of phosphorus in the nervous structures and in the colored blood corpuscles, as well as sulphur and the compounds of sulphur in the muscular structures, undergo more rapid changes than in the normal state ; and phosphoric acid and the phosphates, and sulphuric acid and the sulphates, appear in increased quantities in the urine. The waste of phosphorus and its compounds in the blood corpuscles and nervous structures during the active stages of the fever, is far greater than the supply of these elements

[1] *Observations on some of the Physical, Chemical, Physiological, and Pathological Phenomena of Malarial Fever*, by Joseph Jones, M. D., Prof. Med. Chem. in Med. Col. of Georgia, at Augusta. — *Trans. of the Amer. Med. Assoc.*, 1859.

through the food. During the slow action of the malarial poison, as well as during the active stages of the paroxysm, important changes take place in the liver and spleen. In both organs, the colored blood corpuscles are destroyed in large numbers, and the coloring matter resulting from the disintegration of the red corpuscles accumulates in them, and in conjunction with other changes in the nutritive processes of these organs, produce the alterations characteristic of malarial fever. That the chemistry of the body is still further deranged in malarial fever, is evident by the changes of the excretions. Thus, during the chill, and at the very commencement of the hot stage, phosphoric acid disappears almost entirely from the urine; as the hot stage progresses, and the febrile action and heat commence to decline, there is an augmentation of phosphoric acid. But what is still more important in its bearings upon inflammatory affections engrafted upon the malarious constitution, the uric acid is either increased or remains at the normal standard during the chill, disappears almost entirely during the fever, and then increases rapidly, and rises to a high figure after the subsidence of the febrile excitement, and often continues for days, two or three or even six times more abundant than in the normal state. If it be true that the presence of a morbific agent in the blood, as uric acid in gout and rheumatism, will often prove an excitant to inflammatory action, then the tendency in malarial fever to the generation of large quantities of uric acid during the intermissions, and even during the period of convalescence, is important in its bearing upon inflammations accompanying or following malarial fever.

It results from these effects of the malarial poison, —

Effects of the action of the malarial poison upon the progress of inflammation.

First, When inflammation is excited from any cause in a system subjected to the influence of the malarial poison, the natural tendency is for the inflammation to assume a low form, from the altered condition of the constituents of the blood and structures, and from derangements in the processes of nutrition, and of those physical and chemical acts by which the nervous and muscular forces are developed. It is well known that the causes which are most influential in the production of inflammation are such as enfeeble the heart, impair the tone of the arteries, reduce the activity of the secreting organs, and debilitate the muscular and nervous forces. Imperfect nourishment, also, either in consequence of the defect in the quantity or quality of the food, or of incapacity of the digestive powers, impairs the power of the system to resist the effects of deleterious and depress-

ing agents, as cold, and produces a liability to low forms of inflammation and fever, and to various epidemic and contagious disorders. In malarial fever, even when the digestion is unimpaired, the action of the poison, by impairing the constitution of the blood, and by deranging the nutritive processes of the different organs and tissues, and by deranging and depressing the chemical actions concerned in the development of the physical and nervous forces, produces similar results to those witnessed in ill-fed and ill-conditioned beings. The process of inflammation, whilst including both congestion and determination of blood, is essentially more complex than either or both of these conditions, and includes changes of the blood within the vessels, and changes of the relations of the capillaries to the blood, and of the blood to the surrounding tissues. The character of these changes, as well as the extent and progress of the inflammation, will depend upon the constitution of the blood, the forces moving the blood, and the condition of the forces active in the nutrition of all the organs, as well as of the forces especially active in the inflamed tissues. Thus, when the character of the blood has been altered, and the forces depressed, the solid products of inflammation are less capable of organization, the lymph effused possesses inferior plasticity, and the effects of the local inflammation upon the general system in causing inflammatory fever are more depressing and dangerous.

As, therefore, the tendency of the malarial poison is to derange the conditions upon which the maintenance of healthy nutrition depends, namely, the regular supply of healthy blood possessing a definite composition and fixed relations of its elements, and of a certain supply of physical and nervous force, and the healthy constitution of the organs and tissues, it is evident, not only that inflammation engrafted upon the system laboring under the effects or under the direct action of the poison must be correspondingly altered from its progress in the healthy constitution, but also that the state of the system induced by the action of the malarial poison is conducive to the origin of inflammation.

Second, From the destruction of the fibrin and red corpuscles, consequent upon the action of the malarial poison, the tendency of inflammations excited in systems under the influence of the malarial poison is to diffusion. The increase of fibrin in the blood, and in the inflamed structures, appears to be destined, in the economy of nature, to limit and circumscribe the inflammatory action by the fibrous matter thrown out within and around the inflamed part. The col-

Inflammations excited in systems under the influence of the malarial poison tend to diffusion.

ored blood corpuscles which crowd the inflamed part, appear to contribute by the chemical changes which they excite, and especially by the increased oxidization of the protein elements, to the formation of fibrin, which in this view may be considered as one of the controlling and limiting elements of inflammation. Whatever, therefore, tends to diminish the red corpuscles and fibrin, tends to interfere with the natural processes employed by nature in the limitation of inflammation, and directly promotes the diffusion of the inflammation over a greater extent of tissue, and in a corresponding degree renders it more severe and dangerous.

From these facts and considerations we conclude, that whilst the malarial poison cannot be said directly to produce hospital gangrene, still it is capable of inducing such changes in the blood, and in the nutritive and excretory processes, as alter the usual course of inflammations.

The presence of moisture in the atmosphere has much to do with the development and progress of the simple forms of vegetable and animal life. It is well known that the development of certain plants is attended with the rapid change of organic matter; and whilst it is by no means settled that hospital gangrene is due to the action of microscopic plants or animals, at the same time their rapid formation in unhealthy wounds, surrounded by a hot, moist, debilitating climate, might excite a train of changes in the diseased structures and unhealthy discharges, which might result in the development of the peculiar poison of hospital gangrene.

Again, heat and moisture, independent of the generation of animal and vegetable forms, constitute the most essential conditions to the rapid putrefaction of animal and vegetable matters. The fact that wounds and ulcers are much more prone to unhealthy actions, and even to gangrene, in hot and moist climates, than in cold and dry elevated countries, appears to be due not merely to the debilitating effects of heat and moisture upon the general constitution, but also to the rapid change and decomposition which the discharges and sloughs and dead tissues undergo under the action of these agents. If the poison of hospital gangrene be capable of transmission through the atmosphere, it would appear that a moist, warm, stagnant atmosphere would be the most suitable for its rapid propagation. Moisture that is saturated with the foul emanations from unhealthy and gangrenous wounds, would appear to be almost as potent in its action as the direct application of the gangrenous matter and unhealthy secretions and gases. We are as yet, in a great measure, ignorant of the chemical constitution of

the emanations from unhealthy and gangrenous wounds. Whilst they are capable of producing decided impressions upon the organ of smell, and even upon the nerves of taste, the means of chemical research do not appear adequate to their isolation and analysis.

We might adduce many illustrations to sustain the preceding observations upon the injurious effects upon wounds, of a hot, moist climate.

Injurious effects of hot, moist climate upon wounds. Observations of Dr. Home on ulcers.

Thus, Sir Everard Home, in his "Practical Observations on the Treatment of Ulcers on the Leg, considered as a Branch of Military Surgery," remarks: —

"If ulcers on the leg, when neglected, are found in the country to spread and become a serious disease, it happens in a still greater degree in the West Indies, where the slightest hurt upon the leg, or a small ulcer from the effects of fatigue in that climate, in a very short time become an ulcer of the worst description, and render the patient entirely unfit for service. Too much attention cannot be paid to the conduct of the soldier in hot countries, to prevent ulcers, and when they occur, to put the men as soon as possible under the direction of the surgeon. At St. Lucia, during the American War, I had several conversations upon this subject with Dr. Young, physician to the army, who had been formerly a regimental surgeon, and had served in the Windward Islands in the year 1765, and the three following years. In that period he had made some remarks which led him to conclude that tall men are less able to bear the climate of the West Indies, and are more liable to ulcers on the legs, than others. As his observations are curious, they are laid before the reader.

"Dr. Young observed that in the 32d Regiment there were one hundred and forty-five tall men, and two hundred and seventy-six short men; that in the course of four years twenty-two were discharged from those of the first description, and only twenty-three from the second, on account of ulcers on the legs. The ulcers were of such a nature as to be deemed incurable in that climate. Some of the patients were obliged to undergo amputation, to give them a chance for their lives; others had so many of the muscles and tendons injured as to render them ever after unfit for service. The principal cause why tall men are more subject to ulcers in the legs than short men, Dr. Young conceived to be the length of the column of blood in their veins, which, by its pressure, renders the legs less able to recover when hurt by violence. He observed, at the same time, that tall men are less able to support the heat of the climate, and by losing their general health are rendered more liable to have ulcers on the legs. From these remarks, Dr. Young concludes that many lives might be saved by omitting to send any grenadier companies.

"After having made these observations on the 32d Regiment, Dr.

Young went upon the expedition against Martinique and the Havana, and was surprised to find that ulcers on the leg in another regiment were less frequent, although the mode of life, diet, and all general circumstances were the same, and the fatigue considerably greater. This he was led, in some measure, to attribute to the circumstance of the men wearing half boots of cloth, which defended the legs from many slight accidents occasioned by marching through uncleared paths, by kicks, or the bites of mosquitoes. They also kept the legs dry, and gave a support to the veins, which woolen cloth gaiters from their elasticity will do in a greater degree than those made of leather and linen."

The testimony of Dr. John Hunter, in his "Observations on the Diseases of the Army in Jamaica," is even stronger than that of Dr. Home: —

Testimony of Dr. John Hunter upon the effects of warm, moist climates upon ulcers.

"Sores and ulcers in the lower extremities were frequent at all seasons of the year, and in all the different quarters where the soldiers were stationed. They, together with fevers and fluxes, amounted to nineteen twentieths of the sick received into the hospitals, all other complaints not being more than one twentieth, if particular times be excepted, when the dry belly-ache or small-pox were prevalent. The proportion of sores in the hospitals, though always considerable, admitted of great variation. At Spanish Town and Kingston there were often one third, at Fort Augusta one half, and at Stony Hill two thirds of the whole number in hospital. They arise from the most trifling causes; a scratch, a hurt, or bruise in the lower extremities are sufficient to produce a sore, which is always difficult to heal, and sometimes impossible. Old sores often break out anew, and prove equally obstinate. A common cause of sores is an insect called a chigre (*Pulex penetrans*, Linnaii, 'Syst. Nat.'). It is of the flea kind, and extremely small. It lays its eggs in the skin in an uncommon manner, for it is said to bury itself in the flesh, and become a nidus for its own ova. The part where it has thus deposited itself, after a little time swells, becomes red, and itches much. At this period, it is the common practice to pick out of the skin, with a fine needle, the bag formed by the body of the parent insect, in which are contained the rudiments of the young. If this be neglected, the inflammation increases, suppuration takes place, and an ulcer is formed. The insect harbors most commonly in dust upon the floor or ground, and generally deposits its ova in the toes and feet; and many of the men lost one or more of their toes by ulcers arising from this cause. Sores, in whatever way produced, spread quickly, and form a large ulcerated surface. They give little or no pain, which appears to be owing, in a great degree, to the warmth of the air, for cuts and wounds are found to give much less pain in a warm than in a cold climate. The appearance of the ulcers are constantly varying. At times they acquire the look of a

healthy sore, send forth strong and luxuriant granulations, and begin to skin over; but one night will often put an end to this flattering prospect. The granulations turn flaccid, or even mortify in part, the portion skinned over ulcerates afresh, and the sore becomes larger than ever. After a time it will again put on a healing appearance, and repeatedly run through the same stages. The bones at last become carious, and if the limb be not amputated, or the patient sent off the island, he becomes hectic, and after lingering a considerable time, dies."

"The extreme difficulty and indeed almost impossibility of healing an ulcer in the lower extremities, after it had become of a certain size, necessarily produced an accumulation of such cases in the hospitals. Various means of cure were attempted, the principal of which it will be sufficient to mention shortly, as none of them were attended with considerable success.

"It was supposed, as the soldiers arrived in the island after being a long time at sea, and as they had salt provisions after landing, that they might have more or less of scurvy in their habit, which would render the ulcers difficult of cure. On this supposition they were put upon a vegetable diet, which for a time had good effect upon some, but in the end failed. The powers of the constitution having evidently suffered, it was imagined they might be restored by the use of bark, with a full and nourishing diet. This plan was accordingly tried, and produced at first favorable changes, but was not finally more successful than the former. Alterative medicines, as small doses of calomel, were given, but they did no good. The changes which the ulcers of themselves underwent, occasioned for a time some degree of deception as to the good effects of the treatment made use of; for the favorable appearances of the ulcers, coinciding as to time with the medicines directed, raised expectations at first, which in the end were disappointed. But it must be allowed that in many cases the means employed produced a temporary amendment, and promoted to a certain degree the efforts of nature to effect a cure; yet the powers of the constitution were so feeble, that with all the assistance that could be given, they could not bring it to a completion. They advanced a certain way, but soon fell back again. External applications of various kinds were tried, and what has been said of the internal remedies will equally apply to them; they often produced a favorable change at first, but it was not permanent. Among the different dressings that were made trial of were ointments, sometimes stimulatory, sometimes emollient, sometimes poultices, the common bread-and-milk poultice, and dry lint. An application common among the inhabitants deserves to be taken notice of, as it sometimes had better effects than any of those just mentioned. I mean roasted limes. A horizontal position with quiet did good as in other countries, and if neglected, the progress of ulcers became extremely rapid.

"The general result of all my experience was, that ulcers of some

standing, and of a considerable size, in the lower extremities, could not be healed in that country by any means that we were acquainted with. Instead, therefore, of wasting time in fruitless trials, every opportunity was taken of sending home the men with ulcers, along with the other invalids. The change of air and climate produced great effects; many of the ulcers healed on the passage, and all of them soon got well after their arrival in England, unless when the bones were carious; and of these last many recovered after losing large portions of the tibia by exfoliations, or were finally restored to health by an amputation of the diseased limb. This operation was sometimes performed in Jamaica, but never except under the most urgent circumstances, for it seldom succeeded, owing to the locked-jaw which generally came on in a few days, and proved fatal. I cannot help, therefore, concluding that humanity, as well as the good of the service, requires that all bad ulcers should be sent home without loss of time from the West Indies, unless some more effectual means should be discovered than those with which we are hitherto acquainted."

In a note at the end of his work, Dr. Hunter concludes: —

"I believe the obstinate ulcers that occur so frequently in the West Indies, are to be imputed to the bad habit of body produced by the gradual and insensible operation of the poison or cause of fever upon the constitution. I am led to this opinion by what I had occasion to observe in the West Suffolk regiment of militia. While the men remained of a sallow and unhealthy look, slight cuts or accidents produced sores exactly like those that occurred in Jamaica. The granulations were rather luxuriant, though pale, and their surface somewhat glassy, and the sores were more disposed to spread than to heal. It is true I saw some of them that extended to a large size as they did in Jamaica, yet they had the same appearance, and if the constitutions of the men had continued to suffer by remaining constantly exposed to the cause of fever, I have no doubt the sores would have been as bad as in the West Indies."[1]

Dr. Robert Jackson has recorded similar observations in his works on Fever.[2]

"Ulcer on the legs has been a perplexing complaint among the mil-

[1] London, 1796, pp. 221–226, 342.

[2] *An Outline of the History and Cure of Fever, Endemic and Contagious; more especially the Contagious Fever of Jails, Ships, and Hospitals; the Concentrated Endemic, vulgarly the Yellow Fever of the West Indies. To which is added an Explanation of the Principles of Military Discipline and Economy, with a Scheme of Medical Arrangement for Armies*, by Robert Jackson, M. D. Edinburgh, 1798, pp. 328–331.

A Sketch of the History and Cure of Febrile Diseases, more particularly as they appear in the West Indies, among the Soldiers of the British Army, by Robert Jackson, M. D. Second edition, with many additions, vol. ii. London, 1821, pp. 185–202.

itary in the West Indies, in all periods of medical history; and among others, the expeditions sent to that country in the year 1796 furnish memorable examples of the fact. Berbice and Demerara, settlements on the coast of Guiana, were taken possession of by a division of the force originally destined for St. Domingo. The 93d, one of the regiments sent on that service, was stationed at Berbice, and, according to a report of an officer of credit, little or no sickness, except ulcer on the legs, was observed in it for at least four months; that was, however, to such an extent that in a corps short of five hundred, seventy of the élite were during this time rendered permanently unserviceable. The 99th, another regiment employed on that service, was stationed at Mahaica.

Observations of Dr. Robert Jackson upon ulcers of the leg in hot climates.

"The sickness at Mahaica assumed the concentrated febrile form; the ulcers on the legs were not observed. The 39th, another corps of the expedition, occupied Starbrock. The febrile form of disease was remittent; sores on the legs appeared on some occasions. The sore leg form, according to this statement, was almost sole at Berbice; it did not occur at Mahaica, where the febrile form was continued and aggravated; it occurred occasionally at Starbrock, where the form was remittent and of the milder form." [1]

In the third chapter of this volume we had occasion to quote the observations of Dr. Thomas Clark, upon the constitutional symptoms which ofttimes preceded the appearance of hospital gangrene in the wounds and ulcers of the British soldiers and seamen serving in the West and East Indies; and we will still farther use this authority to illustrate the relations of temperature and moisture to the changes of wounds and ulcers.

"It may be proper here to attempt to account for the sudden changes of sores for the worse that often take place in warm climates, while in cold or temperate regions such changes are frequently not discernible.

Dr. Thomas Clark's views upon the relations of warm, moist climates to ulcers.

"1. In the former, although the temperature of the internal parts of the human body while in health is the same as in the latter, still I believe that of the external and remote parts to be much greater in warm than in cold or temperate climates.

"2. There can be no doubt that the greater the temperature of the atmosphere is, the more rapid will be the progress of dead animal substances to putrefaction cæteris paribus. It is, therefore, only reasonable to conclude, that when fever supervenes, the tendency to putrefaction of the matter of sores will be much greater in warm than in cold regions, granting that the body's temperature in fever were the same in both countries, which I believe is rarely the case, more especially of the external and remote parts.

[1] *A Sketch of the History and Cure of Febrile Diseases*, etc., p. 189.

"Added to what has been now said, there can be little or no doubt that the atmosphere of warm climates, more especially of the West Indies, contains much more putrescent matter than that of temperate climates generally does, and consequently will act as a stronger ferment to all matter capable of undergoing the putrefactive stage of fermentation. The general hospital was at this time very much crowded, and the surrounding atmosphere extremely offensive, owing to the number of extensive and putrid sores. Fever became very prevalent, and often proved fatal. In some instances it terminated fatally in a few days, accompanied with a yellowness of the skin, but more commonly it was prolonged for six or seven days, and upon the whole, resembled typhus more than the violent disease that prevailed in the 6th and 65th Regiments soon after their arrival at Barbadoes.

"It is a melancholy circumstance, that during my stay in the West Indies there was not a single instance that fell under my observation of a complete recovery after amputation, and as far as I could learn, not one perfect recovery was effected in the general hospital under like circumstances. All of the patients either died, or were put on board hospital ships for England. It frequently happened that after a cure was very nearly effected, a sudden change for the worse occurred, and, in the course of a few days, things became worse than they were originally. These unfavorable changes were generally accompanied with fever, or evidently occasioned by a gradual decline of the constitution, or, in other words, were symptomatic affections. What I have said concerning the want of success after amputation, holds good in a great measure with regard to other wounds and ulcers. Before quitting this subject, I think proper to mention that although sores in the general hospital were very troublesome, yet, while in the 65th, we had very few of like description. The only way I can account for this is, that, in the 65th, our patients were more regularly dressed, less crowded, and the use of poultices more general.

"About the beginning of August, 1794, I was suddenly ordered on board the *Atlantic*, hospital-ship, for England, to assist in taking care of from fifty to sixty of the worst of our wounded. By far the greater part of them were confined to their beds, and stowed in small fixed cots, as close as possible between decks. They were unfortunately detained in harbor several days before they sailed. The consequence was that a violent putrid fever broke out just upon our sailing. Almost every one of us on board was seized with it. The greater number of the sores became gangrenous, and a very great mortality soon took place. By the time we had been a fortnight at sea, nearly half our number had died. Soon after we reached a temperate climate, the disease entirely ceased, and the mortified parts, which surrounded every wound to a greater or less extent, now separated, and left, in many instances, very extensive ulcers, and many of those on the legs were attended with

carious bones. I found it necessary to amputate in six cases, in order to save the patients' lives; and if I had done so in more, I believe I might have saved several additional lives. But as the surgeon who had the principal charge of the sick died about a week after we sailed, I was the only medical man left, and had no assistance except that of the attendants on the sick. Being badly supplied with instruments, and little accustomed to operate, it was only when things came to an extremity that I determined to adopt the measures already mentioned." [1]

Dr. George Cleghorn, in his "Observations on the Epidemical Diseases of Minorca, from the Year 1744 to 1749" states the following facts, showing that ulcers are of common occurrence and of an obstinate character in this warm and moist climate: —

Dr. George Cleghorn's observations upon the prevalence of ulcers in the warm, moist climate of Minorca.

"Baglivi [2] tells us that at Rome ulcers of the legs are almost incurable, and wounds in them difficult to heal, while the like accidents on the head are quickly cured without any trouble. The same thing happens here, insomuch that it is a proverb among the natives, 'Minorca is good for the head, but bad for the shins.' [3] This perhaps is owing partly to the redundancy of atrabilious particles in the blood, which, naturally flowing into the inferior branches of the aorta, constantly keep open any outlet through which they have once found the way; partly to the large obstructed viscera compressing the vena cava, and hindering the free return of the fluids from the inferior extremities. Hence we find that ulcers of the legs with black cicatrices (such as may daily be seen among the soldiers and Spaniards) are mentioned both by Hippocrates (De Morb. Interm.) and Celsus (lib. ii. cap. vii.) as the effect of overgrown spleens." [4]

These observations might be greatly extended, so as to embrace the consideration of the greater prevalence of cutaneous affections and various diseases attended with extensive ulceration, as leprosy, elephantiasis, and yaws, in warm, moist climates, than in cold, dry climates. It is believed, however, that the preceding facts are sufficient to illustrate the relations of heat and moisture to the origin of hospital gangrene.

2. *The air of crowded hospitals, tents, and ships loaded with animal exhalations.*

[1] *Observations on the Nature and Cure of Fevers, and of Diseases of the West and East Indies, and of America; with an Account of Dissections performed in these Climates, and General Remarks on Diseases of the Army*, by Thomas Clark, Surgeon. Edinburgh, 1801, pp. 118–124.

[2] *Prox. Med.*, lib. i. p. 102.

[3] "Minorca es bo de Cap. y mal de Camas."

[4] Philadelphia, 1812, p. 44.

The causes examined in the preceding sections should more correctly be termed *conditions* favorable to the development of hospital gangrene.

2. Cause of hospital gangrene the air of crowded hospitals, tents, and ships, loaded with animal exhalations.

Bad diet, and the depressing effects of a moist, malarious climate, may induce such changes in the composition of the blood and structures, and such derangement of the vital and physical forces, as to alter and prevent the natural course of inflammation, and lead to the development of unhealthy and abnormal products and secretions, which may even manifest noxious properties when applied to wounds in healthy constitutions and in a state of sthenic inflammation. Under the prolonged action of these causes, the degeneration of the blood and tissues may proceed to the point of actual ulceration without any external injury. This is well illustrated by the failure of health and strength, and the extensive ulceration of certain portions of the alimentary canal in animals and man, when only one kind of vegetable food is used exclusively.

Organic chemistry applied to pathology has much to accomplish in determining the composition of the blood and tissues under different conditions of diet, and of exercise, and of exposure to different degrees of temperature and moisture. Such an extended investigation of the variations of the composition of the solids and fluids of animals under the action of various kinds of aliments, the chemical constitution of which has been carefully determined, as well as under the action of known physical agents, should manifestly precede and lay the foundation for the correct knowledge of the changes of disease.

Whilst the composition of every organic substance can be determined by analysis, and even the atomic weights of the greater number ascertained with some degree of certainty, at the same time we have obtained by such an analysis only the empirical composition of the substance, and have ascertained nothing with reference to the mode in which the elementary substances are coupled together. As each element has its own definite mode of combining, and has associated with it a definite equivalent of force in the state of gravitation, electricity, heat, and chemical affinity, it is evident that the more complex, the more readily will its properties be altered by a simple change in the grouping of its elements. The highest problem of organic chemistry is to determine the rational composition of bodies; but notwithstanding the exertions of many chemists, it has been solved satisfactorily only in the case of a very limited number of organic bodies.

If, in accordance with Laurent's view, it be supposed that organic compounds consist either of primary nuclei or of secondary or derivative nuclei, or of compounds of these nuclei, with various substances externally attached, as sulphur, phosphorus, and chlorine, each complex constituent of the animal organism may undergo a number of changes as the primary nuclei, or the derivative nuclei, or their compounds with various substances are altered. If an animal be fed upon food deficient in phosphorus or sulphur during the complex changes of nutrition, secretion, and the development of the forces, the grouping of the organic compounds may be finally deranged by the gradual loss of these elements. It is probable also that the poisons of certain fevers may have special affinities for certain compounds, and even for individual elements. By these gradual changes the stability of the compounds may be destroyed, and the constituents of the animal be reduced to that unstable equilibrium in which any disturbing cause may excite the re-arrangement of the individual elements, and the development in this manner of various abnormal and even poisonous compounds. We have reason also to believe that allotropism is by no means confined to inorganic bodies, and that organic compounds may exist in different conditions and manifest different properties without any increase or diminution either in the number or proportions of the component elements, just as carbon may exist in three different allotropic states, one of which is distinguished by its ready inflammability or chemical change, and the other two by their stability and difficulty of combustion. Variations in the composition of the food, as well as the action of various depressing and morbific agents, may induce changes in the properties of certain constituents of the living body analogous to the allotropic states of inorganic bodies.

Deleterious effects upon wounds of the exhalations, which contaminate the atmosphere of crowded, badly ventilated, filthy tents.

One of the most essential conditions and efficient causes of hospital gangrene is found in the exhalations which contaminate the atmosphere of the crowded, badly ventilated, and filthy tent, hospital, or ship. In the present condition of the Confederate troops, exposed as they have been to unparalleled labors and fatigue, with short and unvaried rations, the crowding of the wounded into badly ventilated and filthy hospitals and tents will uniformly be attended by the appearance of hospital gangrene. The severity of the disease will be greatly increased in a damp, warm, low, malarious atmosphere. In a stagnant, moist atmosphere it is almost impossible to secure in the wards of large hospitals, even when the

windows are kept always open, such a constant change of air as will prevent the deleterious action of the exhalations from the wounded surfaces and from the lungs and skin and excretions of the patient. As far as my observations extend, I am led to the belief that the exhalations act not only upon the wounded surface, but also through the lungs and skin, and that by the continuous absorption of these deleterious matters through these channels the nervous system may be so depressed and the constitution of the blood so altered that hospital gangrene may arise independently of local action. This question, however, admits of much investigation and discussion, and we shall endeavor to illustrate the inquiry by the practical observations of others, as well as by our own labors.

It is now at least believed by a large portion of the profession, if not established beyond all doubt, that the animal exhalations of crowded tents and hospitals are capable of developing, even in healthy nurses, two distinct species of fever, characterized by many of the symptoms which manifest themselves in the fever accompanying the severer forms of hospital gangrene. And it is without doubt true that the heavy mortality from pneumonia and typhoid fever in the Confederate hospitals has been due in great measure to the depressing effects of animal exhalations, and it is probable that many cases of pneumonia have been converted by these agents into cases of hospital gangrene of the lungs.

Whether true or false, the belief is nevertheless wide-spread amongst the medical officers of the Confederate army, that exhalations from a gangrenous wound are capable of exciting the disease in all the surrounding ulcers and wounds. This question is by no means definitely settled, and is open for investigation and experiment. The causes which developed one case of hospital gangrene may develop a thousand, or any number, and this doctrine of the rapid propagation of the disease from a single centre, independent altogether of the surrounding hygienic conditions, is exceedingly convenient and comforting to those surgeons who have had numerous cases of the disease, and who have no special belief in the virtue of free ventilation and cleanliness in preventing not merely the origin, but also the spread of hospital gangrene.

Whether hospital gangrene can arise at any time *de novo*, from crowding together of the sick and wounded, and whether the disease can be communicated from one or more cases through the atmosphere of wards, without actual contact of the gangrenous matter, are questions of great importance in their bearing upon the internal arrangement and hygiene of military hospitals.

After careful observation and consideration, the following conclusions have been drawn: —

General conclusions as to the mode of origin of hospital gangrene.

1. Hospital gangrene may at any time arise *de novo* when sick and wounded soldiers are crowded together in badly ventilated houses, filthy hospitals, close box cars, or on shipboard.

2. Hospital gangrene will arise most readily under these circumstances: when the soldiers have been on scanty and poor food, and have been exposed to fatigue, loss of rest, the constant excitements of battle, and the unhealthy atmosphere of crowded, filthy camps, and besieged cities.

3. When crowded together, a large proportion of the wounds may become gangrenous without any direct application of the matter, and before even the dressings have been removed.

4. If cases of hospital gangrene be introduced amongst the sick and wounded of any hospital in which the disease is not prevailing, the rapidity with which it will spread will depend upon the hygienic condition of the hospital, and also upon the elevation of its situation, and the temperature and moisture of the climate.

5. If these propositions be true, it is evident that the crowding of human beings together, whether sick or well, in confined spaces, so deteriorates and poisons the atmosphere, that all wounded surfaces are liable to become infected. As the disease sometimes arises amongst freshly wounded soldiers, without any introduction of the disease from without, and also amongst isolated cases of wounds introduced into hospitals crowded simply with the sick, the conclusion is inevitable that the disease arises as much from the action of air, rendered foul by animal exhalations and by changes in its chemical and physical and electrical constitution, upon wounded surfaces, as from any actual contagious effluvia arising from the gangrenous wounds.

The changes induced upon a confined portion of atmosphere by living beings, are as yet imperfectly understood. In such an investigation, we have not to deal with the mere diminution of oxygen and increase of carbonic acid gas; numerous other gaseous bodies, as ammonia, sulphureted hydrogen, and volatile animal matters, and vapors loaded with various animal secretions and excretions, are given off from the lungs, skin, intestinal canal, and urinary organs. We have as yet but little knowledge as to the effects of oxygen in an active state (ozone) upon the progress of wounds, and still less knowledge as to the relations of the electric changes to diseased processes.

Some of the most striking facts upon which the preceding conclusions rest, will now be given, and others equally important will be presented in the following chapter.

Facts illustrating the preceding conclusions as to the causes of hospital gangrene. Effects of crowding the wounded after the battle of Chickamauga.

The Confederate wounded which were sent to Augusta from the battle-field of Chickamauga, in some cases manifested symptoms of hospital gangrene before leaving the close crowded cars; and amongst the thousand and fifty wounded, scarcely one of those who were crowded into badly ventilated churches and hospitals escaped the disease which attacked a large number simultaneously. It might be objected that as the cars on which these wounded were transported had been used for months before by wounded soldiers, some of whom were suffering with hospital gangrene, the disease in the case of the wounded from Chickamauga may have been contracted from this source, and therefore did not originate *de novo* from crowding and bad hygiene.

Origin of the disease amongst the 200 Confederate wounded after the battle of Jonesboro'.

The origin of the disease amongst the two hundred Confederate wounded who fell into the hands of the Federals at the battle of Jonesboro', who were freshly wounded, and who had been crowded into two buildings never before used as hospitals, and who had been deprived in a great measure of nurses and medical attendance, and whose wounds had not in most cases been even dressed or washed, was clearly the result of crowding and bad hygiene. These facts are open to no objection, and clearly demonstrate the first proposition. These soldiers had been exposed to a long and arduous campaign, from Dalton to Atlanta, and had been serving in the trenches in and around Marietta and Atlanta for weeks, contending with an enemy nearly treble in numbers, and furnished with every appliance of destruction known to modern warfare. By day these men were exposed in the trenches, without covering, to the blazing sun of a southern summer, with their attention constantly strained to avoid the shells or the minie-balls of the sharpshooters; and by night their rest was broken by the bursting shells and the repeated real and feigned attacks of the enemy. It was difficult, if not impossible, to maintain a proper police in and around the trenches and in the Confederate camps.

Effects of fatigue, exposure, and bad diet in developing hospital gangrene in the Army of Tennessee.

During the retreat from Dalton to Atlanta, the Confederates, under General Johnston, were engaged in a series of bloody fights, in which the enemy were successfully but temporarily checked; and owing to overwhelming numbers and the successful flanking operations of General Sherman, the Confederates were compelled to fall back.

The successive abandonment of line after line of defense, and of most eligible hospital accommodations in an elevated, salubrious region, caused the constant crowding of the hospitals one upon another. The continual breaking up and removal of the hospitals attached to the Army of Tennessee, was not only attended with the loss of much valuable property and many hospital stores, but in the almost unavoidable confusion, and in the crowding of the wounded upon box cars and into temporary hospitals, they suffered many privations, and were subjected to such influences as tended to develop hospital gangrene to a distressing and disastrous extent. Many men, who had passed through bloody battles with only slight injuries, suffered untold tortures, and were in many cases either permanently disabled or actually destroyed by hospital gangrene.

Effects of crowding gangrene patients together at Vineville, Geo.

At Vineville, near Macon, the experiment was tried of collecting together from the ten large general hospitals in Macon and Vineville, all the cases of gangrene into a single hospital. The Empire Hospital, located just beyond Vineville, opposite the Confederate States Laboratory, and just where the Macon and Vineville road strikes the railroad, was selected for the reception of the cases of hospital gangrene. This hospital consisted of a series of small fly and hospital tents, pitched in a low, flat spot, from fifty to one hundred feet below the hills of Vineville. The ground was covered with small scrub oaks, not much higher than the tents; and whilst they gave but little shade, they served to interrupt the necessarily imperfect flow of air in this flat spot, surrounded by higher hills towards Vineville, and by a dense growth of pines and oaks towards the north and west. The effect of this measure was to concentrate the disease. The wounded who were sent without gangrene, invariably took the disease; and those who were convalescent from gangrene, in many cases took the disease, and ofttimes perished from a recurrence.

These facts will be more fully examined in one of the succeeding chapters, in which we will also present the mortuary statistics of this hospital.

The cases of hospital gangrene did much better upon the higher hills of Vineville than in the Empire (gangrene) Hospital, and also than in the hospitals situated in the heart of Macon.

The following answer to some inquiries which I addressed to the surgeon in charge of the general hospital at Staunton, Virginia, contains several interesting facts illustrating, in connection with the preceding facts, the fourth proposition: —

THE GENERAL HOSPITAL AT STAUNTON, VA., *November* 19, 1863.

SURGEON JOSEPH JONES, P. A. C. S.,
AUGUSTA, GEO.: —

Surgeon S. L. M. Mérillat on the hospital gangrene of the Staunton General Hospital.

SIR, — Yours of 11th instant, requesting me to communicate to you the results of my observations in regard to hospital gangrene, and suggesting the best mode of keeping a record of such cases, came to hand night before last.

It would give me great pleasure to comply with your request, and to contribute my mite towards the object you have in view, but fortunately I have never had an opportunity of observing in this hospital — and I have been connected with it since its establishment, July, 1861 — the disease described in the books as hospital gangrene.

We have had for upwards of a year past, and have still, a greater or less number of cases, which for want of a better name, we denominate "sloughing wounds;" but this disease appears to have a very slight resemblance to the formidable one described in books as hospital gangrene. It appears to consist in an affection of the cellular tissue, first under the skin, around a gunshot wound, then between the muscles, though it never burrows to any great depth. It destroys the glands and veins in its way, but I have never seen it attacking the muscular fibres, and but very seldom the larger arteries and nerves. If not checked, which is easily done by creosote, nitric acid, chloride of zinc, chlorate of potash, etc., it will extend over a wide surface.

Scorbutic patients appear to be more liable to it than any others, and at least it is more difficult to manage in scorbutic constitutions. It is not often accompanied with evident constitutional derangement. Tincture of iron, taken internally, greatly accelerates the cure, and I believe would do it without local remedies. It is but rarely if ever fatal, and I have seen perfect recoveries in cases in which it had denuded over half a square foot of surface. Its course is not often rapid, and I have never seen it display the frightful rapidity ascribed to hospital gangrene. Another particular in which it differs from that disease, is in the absence of pain. I do not believe that it is contagious, though for obvious reasons we endeavor to prevent the matter from a sloughing wound reaching another wound. I know it is not infectious, as there has been for the last week in the room next to the one in which I write, one of these wounds (now doing well, but about six inches by three or four inches), with four other wounded men, none of whom have been infected by it.

It may be proper for me to add, that the ventilation of the buildings we occupy, is as perfect as high ceilings, large and numerous windows, wide passages, ventilators near the floor and ceiling, and in winter time warm air heating, can make it. To this may be due the exemption which we have enjoyed from infectious diseases, and the now well-

ascertained fact that our patients do better in the buildings than in tents.

With the sincere wish that your labors may be crowned with the most satisfactory results, and with the expression of my readiness to assist them, by any means in my power,

Very respectfully,

Your obedient servant,

S. L. M. MÉRILLAT

Surgeon P. A. C. S.

I am inclined to attribute the mild nature of the disease, its successful treatment, and the apparent absence of infectious or contagious properties, to the elevation and salubrity of the Valley of Virginia, the abundance of substantial food, and the excellent police and thorough ventilation of the hospital buildings, which were constructed upon the best hygienic principles before the commencement of the present war.

We will proceed, in the next place, to examine the facts established by several of the oldest and best observers who have written upon this disease. We will present the facts in an extended manner, for they possess a historical value, as well as a direct bearing upon the discussion and establishment of the propositions now under consideration.

Sir Gilbert Blane, in his "Observations on the Diseases of Seamen," published three quarters of a century ago, thus treats of hospital gangrene, under the head of ulcers: —

Observations of Sir Gilbert Blane upon the gangrenous ulcers of seamen.

"Seamen being more particularly exposed to some of these causes, the cure of ulcers is one of the most important branches of practice in the sea service, inasmuch as they constitute some of the most frequent, tedious, and painful diseases incident to a seafaring life, and not only distress the service by a temporary loss of hands, but are the most common cause of the final and entire loss of men, after a long series of expense, trouble, and inconvenience.

"It is found, from direful and multiplied experience, that not only those who are affected with actual symptoms of scurvy, but those who are exposed to the causes of it, and whose constitution is in such a train as to fall into it, are peculiarly susceptible of ulcers of the most malignant kind, from the smallest injury which breaks the skin. This might naturally be expected, from what has been said of the great debility of the fibres, and the deficiency of the powers of renovation and nutrition in this disease. The characteristic symptoms of such ulcers are, a thin fetid discharge, commonly mixed with blood, which some-

times coagulates on the surface. The ulcerated surface is soft and spongy, generally elevated above the level of the surrounding skin, particularly about the edges, where there are excrescences of luxuriant flesh, which in the more advanced state of the ulcer shoot into a soft, bloody fungus, called by the sailors bullock's liver. Besides the diet peculiar to a seafaring life, I have now to mention another circumstance which has not been much attended to, though it has greatly favored the spreading of ulcers in ships of war.

"From observing in the late war that some ships were much more subject than others to ulcers, though in the same circumstances in point of climate, victualing, and the duties of service, I was led to an opinion of their being infectious. Some facts that have occurred in this war have put this beyond all doubt. From what has already been said respecting infection, it seems difficult to ascertain what diseases may be the subjects of it. It would appear that there is a tendency in all morbid secretions, whether fixed or volatile, to stimulate similar parts in other subjects of the same species to a like action, and to a production of the like matter. As a certain concurrence of circumstances is necessary to render any disease whatever contagious, there may be some that are so rarely so as not to be considered at all of this nature. The doubts that have arisen concerning the existence of almost every contagion, have proceeded from its being observed, that no contagion or infection whatever affects every person indiscriminately who is exposed to it, and that it does not take effect except under a concurrence of circumstances of constitution, habits of life, air, and other undefinable particulars, all and each of which are indispensable in bringing about the effect. A number of delicate and accidental coincidences being necessary to constitute these conjunctures, and the application of infectious matter being only one of these, it is evident how it comes to pass that numbers who are exposed are not affected, and how certain diseases may not be at all infectious, except in circumstances which but rarely occur.

"With regard to ulcers, however, the objection does not apply; for it is evident from the fetor they diffuse, that there is a sufficient quantity of effluvia afloat in the air to serve as matter of infection, and to leave no difficulty in conceiving how it may be conveyed and applied. The truth of the proposition will best be evinced, by bringing in proof of it a few facts out of many that might be adduced to the same effect.

"The *Ganges*, of seventy-four guns, and six hundred men, arrived from the West Indies in the month of October, 1796, with a great many foul ulcers on board, to which the crew had been subject for several months before leaving the West Indies. She was for some time at Spithead, under the use of fresh provisions, and again at Yarmouth, but the ulcers continued to multiply. She sailed on a cruise to the North

Sea, on the 2d of June, 1798, with only two ulcers on board. During the cruise, they prevailed more than ever; and as a proof that this was owing to infection, and not to a constitution depraved by sea diet, the surgeon remarked that the new-raised men taken on board at Yarmouth (of whom a great number were necessary, in order to replace those disabled by ulcers), were much more liable to them than the old seamen from the West Indies. This complaint continued till January, 1798. It then ceased; and the means which seemed to have a principal share in putting a stop to it, were the sending every case to the hospital as soon as it appeared, a strict attention to cleanliness, and a supply of vegetables. From the arrival of this ship in England till this time, two hundred and eighteen cases of ulcers were sent to different hospitals.

"The propensity to this complaint was such that the smallest sore, whether from a hurt or a pimple, fell into the state of an ulcer. Blistered parts also were affected in the same manner. Sores which seemed to be in a healing state, would suddenly become gangrenous. A black speck in the middle was the constant forerunner of this.

"The men who slept near the ulcerated patients were most apt to be seized with them, as also the sentinels and nurses who were about them. The incisions of those who underwent surgical operations, and were placed among them, assumed the same ulcerous state, while those who were placed in a remote part of the ship, healed in a kindly manner.

"Those ulcers were attended with symptoms of the most virulent and malignant kind. They began with violent inflammation, which suddenly terminated in mortification, destroying in a short time the fleshy parts, so as to expose the bone, which soon became carious. They had all the characters of the worst scorbutic ulcers, but they took place in constitutions in which there was no symptom of scurvy, nor did they yield to lemon juice.[1]

"The *Triumph*, of seventy-four guns and six hundred and fifty men, had been employed during the greater part of the war on the coasts of Great Britain and Ireland. During summer and autumn, 1798, she was chiefly employed in cruising on the coast of Ireland; and at that time the crew was subject to malignant ulcers. Eighty-four were put on the sick list from May to December, both months included. Not only wounds and blisters fell into the ulcerated state, but a scratch or boils were subject to the same accident. Sores which seemed to be in a healing state would suddenly, and without any visible cause, spread again, and become foul and bloody, extremely painful, and resisting every means of cure. This unfavorable change always began, as in the *Ganges*, with a black spot in the middle of the ulcer, a symptom which

[1] This account is taken from the journal of Mr. Duncan Macarthur, surgeon of that ship.

seems peculiar to this infectious sort. The manner in which they begin is also characteristic of their nature. The surgeon of the *Triumph* agrees with the other gentlemen in describing their beginning as attended with violent local inflammation, great heat, and a full and strong pulse for several days.[1]

"An incident occurred about two months after the men belonging to the *Triumph* had been sent to the hospital-ship at Cork, which affords a further proof of their infectious nature. Twenty-seven of these men were sent from thence as invalids to Plymouth in the *Atalanta*,[2] sloop of war. The same sort of ulcer spread among the crew of this sloop, seven of whom were affected with it during the passage.

"Ulcers of the same kind prevailed to the most dreadful degree in the ships serving at the Cape of Good Hope, and the naval hospital there, in the years 1796 and 1797, producing the most severe and protracted sufferings, terminating frequently in the loss of limbs, or life, or both. Nor were they confined to the lower extremities, so that the ossa ilium, the scapula, and cranium, would sometimes become carious. Their description is the same as has already been given; but in addition to the symptoms already enumerated, the lymphatic glands in the ham and groin sometimes swelled, the buboes in the latter suppurated, and they not only healed kindly, but the ulcers of the legs looked better while this suppuration continued.[3] These ulcers were much more prevalent in some ships than in others, and they did not arise in any of them on their first arrival, at a time when the men were most highly scorbutic, but some weeks afterwards, though they had the advantage of the refreshments of the country; and they could, in some instances, be traced from the intercourse of one ship with another.[4] I was informed by the surgeon of one of the ships of the line on that station, that some men having been sent from thence to the hospital for the cure of other complaints, they were seized with malignant ulcers originating from scratches or slight sores, although no ulcers of that description prevailed on board of the ship at that time, and although the men had the advantage of fresh and vegetable diet at the hospital. These circumstances are all in favor of their proceeding from infection and not from climate, nor anything peculiar in the circumstances of the service on that station.

"It became frequently necessary to amputate at this hospital, and it was observed that if the patients who underwent the operation remained in the wards with the ulcers, few survived, owing to the gangrenous

[1] This account is taken from the journal and letter of Mr. Thomas Moffat, surgeon of this ship.

[2] Weekly report of that ship, 8th December, 1798, by Mr. Arthur French.

[3] These facts are taken from a letter of Mr. McAllum, surgeon to the hospital.

[4] Two bad ulcers, which were on board of the *Trusty*, of fifty guns, when she arrived at the Cape, were soon afterwards cured; and the bad ulcers first appeared again in some men, upon their return from a ship to which they had been sent.

and ulcerous state of the stumps; but when they were carried into a separate apartment, there were very few of them who did not recover.

"It was observed, both on the ships and at the hospitals where this species of ulcer prevailed, that the hands of those who dressed them, when the skin was broken, fell into the same kind of ulcer.

"The contagious matter of ulcers, like all other infections, stimulates those parts only which are similar to those of the subject which produced it. Except, therefore, when the matter or effluvia lights on a suppurating surface, it does not appear that it proves at all noxious to health. It cannot fail of being drawn into the lungs, or swallowed with the saliva, yet no bad effect ensues; for many ship's companies affected with this complaint, were extremely healthy in all other respects.

"It resembles the specific infections producing febrile complaints in this respect, that the parts become insensible to it after a certain time, like the small-pox, for they take on a healing disposition; but it differs from them in this respect, that after a certain time these parts recover their sensibility to its action, and again fall suddenly into the foul spreading gangrenous state, as is mentioned in all the accounts of this complaint.

"Whether this infection depends in all cases on a concentrated state of the effluvia of scorbutic ulcers, or if it is generated by the peculiar disposition of individual cases, is a question I am not able to resolve; but I hope its history has been sufficiently investigated to lead to some valuable practical inferences with regard to the prevention and cure of these ulcers."[1]

Mr. Leonard Gillespie, surgeon of the royal navy, who published in the sixth volume of the "London Medical Journal," 1785, the first accurate account of hospital gangrene in the English language, under the title of "Observations on the Putrid Ulcer," thus describes this affection, as it occurred in the West India settlements: —

Dr. Gillespie on putrid ulcers.

"The putrid or scorbutic ulcer proved to be one of the most troublesome, inveterate, and dangerous diseases which afflicted the British seamen employed in the Leeward Islands during the late war.

"I prefer the name of putrid ulcer to any other, because the marks of putrescency always were evident to the senses, although those of scurvy were not. It in general did not attack the ships' crews until they had been at least a year in the West Indies; and it often seemed to rage epidemically on board certain ships, whilst others remained in a great measure free from it. Thus, his majesty's ships *Ajax*, *Montagu*,

[1] *Observations on the Diseases of Seamen*, by Gilbert Blane, M. D., etc., third edition. London, 1799, pp. 500–513.

Russel, and *Triumph*, in the beginning of 1781, landed a great number of men on Pigeon Island, St. Lucia, with ulcers of the most malignant nature, whilst several ships in the fleet which had been employed the same length of time, in the same climate, and on the same service, remained in a great measure free from such complaints. It often affected those who began to recover from fever or dysentery, and those who had other symptoms of scurvy; but it often occurred to those who had been healthy during their continuance in the West Indies, and most generally after having received a wound or contusion, however slight, particularly of the lower extremities.

"The wounds of seamen, received in the general actions, were generally affected with this putrid exulceration, and horrid were the devastations made by it. Those who had been formerly affected with ulcers of the legs, seldom escaped a return of this complaint, after having been some time in the country.

"The bites of mosquitoes often gave occasion to this disease, and sometimes, without any evident exciting cause, a small pimple made its appearance on the leg or foot, which, on being scratched, oozed out a small quantity of serum; an inflammation of a livid reddish color and diffused appearance generally succeeded; and when in this state warm fomentations and poultices were applied with a view of discussing the inflammation, the ulcer soon began to spread; a fetid corrosive ichor was discharged, which soon acted on the surrounding parts, and in the space of a few days produced a foul, sloughy, gangrenous ulcer. A considerable degree of fever generally accompanied these external appearances, with great thirst and restlessness. It generally happened when the complaint affected the extremities, particularly the lower ones, that the lymphatic vessels and glands of the part were more or less affected with swelling and pain. When the disease attacked the leg, it seldom confined itself to the soft parts. The sloughy, gangrenous disposition frequently affected the periosteum of the tibia, and was accompanied with the most excessive pain; large and profound sloughs were formed, the limb became œdematous, and hemorrhages often occurred.

"In the autumnal months of the year 1780, I had an opportunity of seeing about two hundred cases of scorbutic ulcers in the naval hospital at New York, some of which belonged to the ships of the West India squadron, which was then at that place, in order to avoid the hurricanes; others belonged to the American squadron. The hospital was well provided with everything necessary, as well of diet as medicine. Every attention was bestowed in order to keep the sores clean; bark and wine were liberally dispensed, and opium was not sparingly administered; but in vain were cataplasms, fomentations, and warm dressings applied, as they seemed evidently to hasten the rapid progress of the disease. Precipitate powder, which was proposed and tried as a detergent, produced still worse effects, and simple dressings of lint were very

far from putting a stop to the rapid putrefaction. Numbers of men were rendered unfit for service. Amputation was had recourse to in some instances, but with very indifferent success, as the sloughy disposition generally made its appearance on the stump, and a great many men lost their lives by this dreadful disease, in which one may literally be said to die by inches.

"Finding the inefficacy of simple dressings, and the very bad effects attending the use of warm poultices and fomentations, the powder and decoction of bark were tried, but not with any very obvious effect. Vinegar and water answered much better; but what answered the best of any was a solution of the gummi kino in equal quantities of claret and red port; by the use of this, the large, fetid, bloody discharge was diminished and corrected, and a stop was put to the exulceration.

"In the beginning of 1781, a naval hospital was established on Pigeon Island, St. Lucia, which was soon crowded with patients affected with the most dreadful ulcers. The progress of the disease, as might naturally be expected, was much more rapid in the hotter climate of St. Lucia than at New York; and what tended much to increase the malignity of these complaints, was the excessive scarcity of all vegetable productions, the hurricane which happened in October, the preceding year, having destroyed them.

"The same plan of treatment was followed here as at New York. Bark, wine, and opium were administered internally, in as large quantities as they perhaps ever have been administered. A solution of essence of malt was allowed as common drink; but I could not then, nor have I ever observed any considerable effects from that substance, which was furnished to the ships in the West Indies, during the war, at such considerable expense. This I am confident of, that had one half of the money been laid out even on sugar-canes, or their juice, they would have been found a much more serviceable anti-scorbutic.

"The external applications were either warm poultices or cold fermented ones; lint, dry, or wetted in vegeto-mineral water, pledgets of cerate, etc. We pursued this mode of treatment for some time, and were inclined to attribute the bad success of it to the want of fruit and vegetables; but when we found these were not sufficient to check the rapid progress of the disease, we gladly pursued a different course. We lost a very considerable number of men by this disease during the first five months after the establishment of the hospital. When the complaint affected the leg, its general progress was from a trifling sore, often proceeding from a hurt, till it became surrounded with an erysipelatous inflammation, discharging an ichorous matter which darkened the lint applied to it, and afforded the most fetid smell; blood was often discharged in a thin, dissolved state, sometimes by an oozing from the entire surface of the ulcer, and at other times from small vessels, the

mouths of which, though visible, were with great difficulty closed, owing to the great degree of putrefaction. There was generally some pain and tension of the inguinal glands; a considerable degree of fever attended the first stage of the complaint, with great thirst; the belly was inclined to be bound at first, but, as the disease advanced in its progress, a dysentery or diarrhœa generally made its appearance, and in the end carried off the patient. The disease was sometimes more rapid in its progress, and in the course of a few days seized on and denuded the tibia, whilst large pieces of integuments and cellular membrane were found to be entirely mortified."

Mr. McDowal has given the following account of hospital gangrene, as it prevailed on board of the *Prince of Wales*, during a voyage from the West Indies to England: —

McDowal's account of hospital gangrene as it prevailed on board the *Prince of Wales*.

"On the 11th of April, 1800, we received on board his Majesty's ship *Prince of Wales*, a number of bad cases of ulcer from Martinique Hospital, where many were laboring under that complaint in the worst stages. From this period, to us unfortunate, as it was peculiarly distressing to the miserable sufferers, every, even the slightest scratch or hurt, in whatever manner inflicted, degenerated into a bad ulcer. The soldiers of the 43d, who came on board at that time, were not exempt; and so alarming was its progress, that on our arrival in the Downs, fifty-six were on the list of ulcer: mostly bad cases.

"That it was highly infectious, appears pretty clearly proved from the following circumstances: Of the fifty-six who were attacked, forty-five were sent to the royal hospital, Deal; the others remained on board; and the temporary sick bay, in which they had been heretofore, being pulled down, they were put into the old bay on the opposite side, which was previously well washed, sprinkled with vinegar, and every mode of purification usually adopted was employed; but, above all, cleanliness was particularly attended to. The dressings were frequently and speedily removed; the bandages, trousers, etc., which had the least chance of retaining the noxious miasma, were either destroyed or well washed and aired.

"The consequence was, that the few cases that remained on board soon got well by the same treatment and regimen (water only excepted, of which we got a fresh supply), and what is still more remarkable, several of these were toe-nail cases, which we always found more obstinate. And I here beg leave to remark, that the ceruss. acetat. sprinkled over the ulcerated toe, was very rarely found to fail of success. What still more confirms the opinion of its being infectious, several people who had cuts and scalds, on applying, had cerate and lint given them to dress them below; and *all* those healed in the usual manner.

"The infectious ulcer assumed various appearances in the different

stages of the complaint; but in general, after a slight hurt, scratch, or wound, an erysipelatous kind of inflammation surrounded the injured part, and in the course of a few hours a small vesicle containing a brownish-colored fluid was observed; on this being evacuated, a brown puncture appeared nearly in the centre of the above mentioned vesicle, which discharged a thin, acrimonious serum. This morbid point spread rapidly; febrile symptoms generally accompanied this stage, frequently delirium. The edges were reverted and painful; the sore of a brown color, and covered with a deep, tough, fibrous slough; the discharge thin and acrimonious, sometimes destroying the surrounding cuticle. In a few days the depascent stage seemed stationary, and a healthy action was just perceptible, by the slough becoming detached from the edges of the sore. In two or more days the slough was commonly cast off, leaving the sore perfectly clean, with a fine, healthy, granulating appearance. Things proceeded in this manner for some time, in some instances till the sore was half or more healed up, tantalizing us with the hope of a speedy cure, when a small part of a granulating surface, mostly near the cicatrice, put on a crimson redness, in the centre of which a dark-colored speck made its appearance, spreading rapidly as before over the whole formerly ulcerated surface, and often twice as much of the surrounding sound parts became a prey to its devouring influence. In the course of this stage of the disease, its appearance was singularly striking. The destroying power of the infection spread regularly from one side of the sore to the other, in a uniform and well-defined line.

"Hemorrhage, in the more advanced stages of the disease, was a very frequent and troublesome symptom, and as far as I could observe, best relieved by the application of cold water over a simple dressing.

"The fetor was peculiar and extremely offensive; to correct which, the air was kept highly charged with nitrous gas, especially during the time of dressing. The only effect I ever could observe from the exposure of the ulcers to this gas, was a slight additional degree of pain, probably from the precipitation of its chemical combination with atmospheric air.

"In several cases the denuded muscles were amazingly enlarged, and diseased throughout their whole extent, resembling an oblong bladder, the outer membrane being of a pale white color, and full of a thin, whey-colored liquid, which issued out in considerable quantity on its being punctured or cut into.

"In one instance, in which the sore was induced by a drop of boiling pitch falling on the anterior and lower part of the leg, it degenerated into a foul, extensive ulcer, in the manner aforesaid, in spite of the unremitting attention of Mr. Chives, the surgeon, in assiduously administering the remedies usually employed, namely, chinchona, lime-juice, wine, and a light, nutritious vegetable diet; slight evacuations, with

emollient poultices and fomentation, in the first stage; and spirituous embrocations were employed latterly, with a full allowance of nutritious regimen, and an increased proportion of sound port wine at intervals through the day. The sore, by repeated depascent stages, occupied one third the extent of the tibia, and more than one half the circumference of the leg. The tibialis anticus muscle appeared in the middle of the sore, in the form already mentioned, entirely detached, only at the superior and inferior edges of the sore, when it stretched towards its origin above and insertion below. A probe being passed under it, and gently raised up, the entire remains of the muscle, from its origin to its insertion, came away without pain, the patient feeling, according to his own expression, only a creeping sensation along the bone. The muscle appeared in a dissolved state, and consisted chiefly of longitudinal fibres, loosely connected by a vascular substance, full of whey-colored fluid." [1]

Dr. Thomas Trotter, in his "Medicina Nautica," has given an interesting account of the hospital gangrene as it prevailed in many of the English ships; and in the second and third volumes of his work, has collected the observations of a number of British surgeons upon this disease, under the name of the malignant ulcer.

The following extracts from the second and third volumes of Dr. Trotter's work will present a correct view of the observations of the author and his associate medical officers: —

Observations of Dr. Trotter on the origin and prevalence of hospital gangrene in the British navy.

"In the spring of 1797, I was informed by Mr. Caird, surgeon of the *Queen Charlotte*, that a number of their people were afflicted with ulcers of a most obstinate nature, and not yielding to the usual remedies, either general or local. He was under the necessity of sending many of them on shore to the hospital, when a change of situation did not seem to operate much in their favor. In this state his sick list continued for some weeks, and as the weather became milder in temperature, he did not observe any disposition for the better in the condition of the sores, which now increased in number. Several men that had been bled for inflammatory diseases, such as catarrhs, sore throats, etc., complained that the orifice in their arms did not heal kindly, but became painful, somewhat swelled, hard, of a livid red color, and which excited strong suspicions that the wound had been made by a foul lancet, that had been employed for other purposes, such as opening abscesses, that could communicate infection. This opinion, however, was soon given up; for other lancets, known to be in perfect order, and used by different mates, did not prevent similar appearances in other patients. Mr. Caird had at one time so many as twelve of this description in his list, in one of whom the affected part swelled and inflamed rapidly, ulcerated and

[1] Trotter's *Medicina Nautica*, vol. iii. pp. 484–489.

spread, till it assumed so bad an appearance that he was sent on board the *Medusa*, hospital-ship, about the beginning of May, while the fleet lay at St. Helens. The patient was a strong, healthy young man, and a seaman stationed in the maintop. The wound that was originally made with the lancet was now an ulcer of the size of a crown-piece, covered with a sloughy matter, black and fetid; the edges of the sore were ragged, and, for a considerable space, round, hard, and livid; but a degree of shining redness extended much further, with tumefaction both above and below the ulcerated part. The pain was excruciating, extending downwards to the ends of the fingers, and up to the shoulder and armpit. The lymphatics leading to the axilla could be distinctly felt, but the glands above were not enlarged. Violent rigors accompanied this condition of sore, resembling the cold stage of an intermittent, alternated with heats and sweating, but not producing a solution of the fever; thirst, sickness, and vomiting were also concomitants. The eyes and countenance were flushed, severe headaches, and not without slight delirium at times; the pulse, though frequent and full, was by no means hard. He was not bled, as the accident was caused by that operation, but he took brisk purges of calomel and jalap, in order to bring him down. The application to the arms was fomentations and emollient poultices. Such was the treatment of the ulcer during the time the fever and inflammation subsisted, and poultices were continued till the sloughs separated, with which the febrile indisposition disappeared. After this, the surface of the sore looked clear and florid. A considerable hemorrhage took place from one of the veins being eroded, but was soon restrained by gentle compression below the ulcerated part, and did not return.

"This ulcer sometimes yielded so little pus that it was difficult to remove the dressings; and whenever it seemed disposed to assume this condition, we made free with stimulating ingredients, either sprinkled over the surface or mixed in the ointment, the chief of which were hydrar. nitrat. or ærug. æris. The patient often complained of pain in the affected part, and there was always a necessity for a large dose of tinct. opii at bed-time. This pain, when violent, always foreboded some change in the complexion of the sore that indicated the application of metallic salts. He also took bark at this time.

"After the fever subsided, it was surprising to observe the great debility that followed, and a degree of emaciation that could scarcely have been expected. But as the appetite returned, the strength was quickly recruited by a diet at once delicate and nourishing, and which afforded plenty of variety, so that the stomach was never palled with a repetition of the same kind of food. In six weeks from the time he left the *Queen Charlotte*, the ulcer scarcely needed a pledget, when he was sent on shore to the hospital with others. He was afterwards

invalided, from the stiffness and contraction that remained below the elbow.

"It is to be remarked that the *Queen Charlotte* had, previous to the appearance of this ulcer, been long in harbor, where the men were living on fresh beef every day, with abundance of vegetables, and all the subjects of ulcer were in the prime of life.

"The fleet went to sea about the middle of May, and in a very short space after, other cases of ulcer, with the same general character, appeared on board the *Queen Charlotte*, and were sent to the hospital. Some of them began from slight scratches and bruises, but in violence of symptoms, and the great extent of surface which the sore occupied in a few days, were infinitely beyond that described above. In the beginning of May the weather was rather cold for the season, but towards the end of the month it was warm.

"When I visited the fleet at St. Helens, there were some bad cases of ulcer in the *Royal Sovereign* and *Terrible*, but nothing unusual was taken notice of in the appearance they put on, nor had they yet shown the least tendency to become malignant.

"On the 10th of June, the objects for hospitals in the different ships were, by signal, sent on board the *Medusa*, to be carried to port, which increased our number to sixty-five, the greater part of whom were ulcers, and evidently of a peculiar kind. The *Saturn* also sent some bad cases. In all our hospital practice, we never beheld so many ulcers together that had in so short a space extended over the whole limb, whether leg or arm, with a loss of muscular flesh great beyond example, and leaving the bone quite bare almost the whole length. Some of the *Royal Sovereign's* people were afflicted in the back and shoulder, where blisters had been applied, that soon degenerated into this foul, fetid, and malignant state of ulceration. Even the scalp was not secure against this disposition of wounded parts.

"After the fever subsided, and the first sloughs fell off, and the surface appeared tolerably healthy and florid, our hopes of the sore going no deeper were sometimes disappointed. Little florid granulations, resembling small strawberries, and not unlike the healthy process of nature in a well-conditioned sore, would frequently appear over the whole surface, or on particular parts, but scarcely poured out any matter. These would sometimes disappear before the next dressing, seemingly by absorption, after which the tendon or bone beneath would be left entirely bare. The sore at this time had not the least fetor. In those cases where a large portion of integuments and muscle had sphacelated, the slough of the patient had sunk inconceivably fast, and extreme emaciation in the course of a few days was the consequence. Our wine was of the best quality, and, when desired, was allowed in due quantity; but we were also well stored with fine bottled cider and London porter. These articles seemed to snatch some of them from the

very verge of dissolution, and they were occasionally changed for punch made from the fresh lemon. We had at the same time abundance of oranges, and eggs cooked in various forms of pudding. These cases were landed at the hospital; some terminated fatally, and a few amputations took place; but other particulars I have not been able to learn.

"Amidst this group of misery, the state of a man from the *Saturn* was singularly shocking. He justly blamed his own indiscretion, and thus described his disease: He had, while in port, contracted a virulent gonorrhœa; but no uncommon symptoms attended, till he returned on shore with leave for a few days. He drank to the quantity of a bottle of raw spirit, in the space of a few hours; the effects of which were next morning apparent in the inflamed state of the urethra and parts adjacent. The glans penis swelled rapidly, and a paraphymosis was formed that produced extreme pain; the urine flowed only in drops, and added to his torment. He also had an acute fever, and transient delirium from the pain. It was in vain that Mr. Seeds employed the full force of an anti-phlogistic regimen, such as profuse bleeding, quick purges, fomentations, and plentiful dilution. The symptoms advanced by too hasty strides to be arrested by any resources of medical skill. The gland of the penis soon dropped off, but the misery of the patient did not stop there; the whole body of the penis passed quickly through the stages of excessive excitement and inflammation, to complete gangrene and mortification, and separated at its very crura. The whole length of the urethra to the bulb sloughed away, and also the scrotum, leaving the testes and spermatic vessels barely covered with cellular substance. He died.

"Cases of this kind have been frequent in ships, from the inordinate stimulus of vinous spirit; but there was reason to believe that in the present instance there was a disposition in the body to malignant ulceration, but certainly aggravated by the quantity of spirit taken into the stomach, which, from its undiluted form, was more likely to induce instantaneous inflammation; the complexion of the parts also confirmed this supposition, and it is to be remembered that the patient came from a ship that had the malignant ulcer on board.

"In blistered parts, which assumed the characteristic appearance of this prevailing malady, there were particular spots that, inflamed, became dark-colored and sloughy, which spread in all directions, till the whole extent of the blister was ulcerated. Numerous little vesicles appeared on the margin, to a considerable distance, with inflamed edges; these quickly broke, turning of a dark-red color, in some places united with the large sore, and gave the whole an indented appearance, somewhat resembling peninsulas in a sea-chart. The vesicles appeared to be lymphatics, inflamed by the absorption of the cantharides, which instantly partook of the general disposition to gangrene. During the

whole of this process, an acute and violent degree of fever raged, with unusual pain of the affected part, which continued till the inflammation on the margin of the ulcer subsided, and the sloughs fell away. This commonly happened in four or five days; but in some cases the inflamed portion turned black and mortified, with a fetid discharge, in less than fifty-eight hours.

"Contused spots, even when the cuticle was not broken, were not exempted from this general tendency to ulcer. But parts that had been scalded or burnt, above all other accidents, most quickly assumed the nature of this horrid sore, spread and inflamed more rapidly, and in the end put on the most formidable appearance; deeper and larger sloughs were the consequence, and symptomatic fever violent in proportion. This was a general remark in every ship.

"Even in the early stage, and sometimes before the cuticle had burst so as to expose the naked surface, buboes appeared in the groin and axilla, not to be touched without much pain, and always attended with fever. These, however, seldom suppurated; but when they did, they constantly exhibited the complexion of the parent sore. In the *Terrible*, the glands of the groin were more liable to be affected than was observed in the other ships; and in the *Triumph* only I have heard of them suppurating.

"Although for the most part these ulcers spring from some external injury, yet we have met with a number of cases when neither wound, puncture, scab, or contusion, could be said to have first taken place. A small circumscribed red spot would be first perceived, scarcely to be felt, but in a few hours rising to a pimple, becoming black in the centre, and inflamed round the edges, till it increased in size, swelled, and assumed every characteristic symptom, with concomitant fever and subsequent ulceration, sloughs, and fetid discharge.

"During the campaign of 1798, we had fresh horrors to encounter. The *Terrible* had never been completely free, but the *Royal Sovereign*, *Glory*, and *Triumph* have been great sufferers indeed. The description and progress differ little from the preceding account; but from the multitude of severe cases that have occurred, the surgeons of these ships have had more laborious duty to perform than has ever been known in the Channel since our attendance. Of all diseases that are liable to accumulate in a ship, one of the most improper must be such an ulcer as we are describing. Dangerous in its disposition and issue, generating a matter fetid beyond compare, the very atmosphere near the patient possesses a degree of pestilence that cannot be sufficiently corrected in a common sick-berth. But if, as is generally asserted, this ulcer is of a contagious nature, the first thing to be done for the relief of the unfortunate sufferer ought to be immediate removal from the ship; and this also is the only certain security for the healthy part of the crew. But in situations of this kind at sea, how is the strength of a patient to

be sustained without food suited to the weak condition of the stomach, and the nature of his affliction? The second stage of this ulcer is marked by emaciation, and the utmost debility, and a discharge of matter from an ulcerated surface, sometimes most profuse and exhausting. If the former service of the fleet so strongly proved the utility of an hospital-ship, the want of one was now equally remarked. The timely removal in the preceding summer soon lessened the number of patients in these ulcers, while at the same time the diet was such as to afford them every delicacy and comfort; besides all the advantages to be derived from lodging, cleanliness, and nursing.

"The following extract of a letter from Dr. Browne, of the *Royal Sovereign*, dated at sea, the 18th of August, 1798, will give some idea of the situation of his sick-berth, from this pestilential sore: —

"'Since I had last the pleasure of seeing you, we have been miserably harassed by those ulcers of the very worst kind; and the rapidity with which the slightest injury to the skin degenerated into ulcer, and the havoc it made on the surrounding parts, in a few days, often hours, were far beyond anything I had ever met with, in either East or West India stations. I have, at present, thirty-seven in my list, in this horrid ulcer; and some of these of very large size indeed. When the ship was paid, we had but few in this complaint on board; and these were in a healing way, and promised so fair that I did not think them objects for an hospital. Two days after we sailed from Cawsand Bay, I was alarmed to find many of my sores nearly cicatrized, displaying on the inner edge of the cicatrix a watery bladder, with a dark-brown or black spot in the middle. This was the focus whence the flame spread; and in the space of three, four, or five days, destroyed not only the labor of many weeks, but enlarged wounds to three times their original dimensions; eroding integuments, muscles, tendons, membranes, and even the bones themselves. Wounds on the body, head, etc., were equally affected with the extremities. In short, I never met anything like it in the course of my practice. The patients had violent fever, ushered in by uncommon rigors and tremor; with such intolerable pain in the affected part, that opium seemed to have lost all its powers of giving relief. Some of them had a severe singultus during the sphacelation, and others, violent vomiting; in either affection, ether and opium afforded little mitigation of the symptoms; bark and wine had no apparent effect. The powder of ipecac, administered in three and four grain doses once and sometimes twice a day, gave more relief in the febrile state than any medicine I tried. This was our situation nearly a fortnight, and seemed quite the rage of a pestilence. I have now got my sores reduced to a more promising state; but the devastations occasioned in that short period will be the cause of several men losing their limbs. I have only ventured on one operation, a small one, a part of the hand, — it promises well, this being the third day, — for nothing could tempt me to such a step during the rage of the contagion. . . . . Our sores while sphacelating and sloughing off, were attended with such an intolerable stench, that the dressers and attendants were often obliged to leave off for a few minutes.'

. . . . "It appears from the following communication of Mr. Thomas Moffat, that the ship's company have also suffered in a severe degree

from this pestilential sore. The *Triumph* (to which ship Mr. Moffat was attached) joined the fleet of Lord Viscount Duncan, a short time before the victory over the Batavian fleet, but returned to Portsmouth, and accompanied the Channel squadron last summer.

"'TRIUMPH, AT SEA, 9th *July*, 1798.

"'SIR, — Agreeable to your request made in the circular letter of April last, and urged by daily proofs of its havoc, I have directed my attention, in a particular manner, to the investigation of the nature and causes of that species of ulcer which has lately been so destructive in ships; and on such an important subject it pains me much that I have so little satisfactory to offer.

"'My first knowledge of its existence was from a man superficially wounded on the leg in the late action in the North Sea, being sent to Haslar Hospital in October last, where it ran through the course hereafter described, and spread so much as to render amputation necessary: the stump soon after attacked in the same way, and in a short time caused his death. About the same time it made its appearance on board, but without being much attended to till March last, when every scratch, even the puncture of a lancet in bleeding, became a formidable ulcer, occasioning in a great variety of instances, buboes in the groin and armpit, which generally suppurated; the skin, after the application of a blister, healed with much difficulty, and rarely without spreading and inflaming considerably. Scalds more than any other species of injury were observed to terminate in this manner.

"'For some days after the wound or other injury was inflicted, everything went on well; when suddenly a violent fever came on, generally towards evening, and continued without any intermission for two or three days, sometimes a week; the sore meanwhile becoming inflamed and livid for a considerable distance around, throwing off very deep and fetid sloughs, of a grumous appearance, till the sore was twice or thrice its former size, with a ragged surface as if gnawed by a dog, and high reflected edges. As it ceases to cast off sloughs, the fever subsides, and frequently both are over in two nights. After a length of time, more or less in different cases, when the sore had been brought to a healing state, it has frequently run the same course over again several times successively.

"'I have no doubt of its being contagious. Last summer it existed in the Channel fleet, while in the North Sea it was unknown, and as soon as we came round to Spithead it made its appearance on board. Several cases of ulcer and scalded feet, that have been kept entirely separated from the ship's company, have healed kindly, while others in exactly similar situations have required three or four months to heal.

"'I have lately confined to the sick-berth very bad cases, and dressed them there; since which fewer sores have been infected, and these appear to have lost a great deal of their original malignity. . . . . By separating every man who appears infected from the others, I entertain hopes of extirpating it entirely from the ship, or at least circumscribing its ravages . . . .

"'THOMAS MOFFAT.

"'TO DR. TROTTER.'

"Such is the brief history of this virulent sore, as it has afflicted the seamen in the ships in the Channel. It has also been common among

others in Lord Duncan's fleet, particularly the *Ganges*, but we have obtained no information from that quarter.

"The striking peculiarities of this ulcer are: —

"1. Its rapid progress, by which, in the space of a few days, it passes through the various stages of inflammation, gangrene, and sphacelus, when the injured parts slough away, which puts an end to an acute concomitant fever.

"2. It has been observed to prevail more in ships in port than at sea, or very shortly after leaving the harbor.

"3. It has never assumed the complexion of a scorbutic ulcer, which is distinguished by the dark-colored fungous mass laying over its surface, that on being removed is quickly regenerated, and is commonly attended with some symptoms of scurvy, such as soft swellings of the legs, spongy gums, and sallow looks: on the contrary, in this ulcer, when the putrid parts separated, the surface is of a light florid color. The scorbutic sore is seldom painful: our ulcer is attended at times with exquisite torment.

"4. It has not been relieved by large quantities of lemon-juice, even to a bottle per diem; nay, we have thought that in some cases, much harm was done by this practice in the first stage.

"5. We have not been able to distinguish particular constitutions more liable to be affected with it than others, except the strong and robust, nor have seamen been more exempt from it than landsmen.

"It has occurred in ships where every attention is paid to exact discipline, cleanliness, ventilation, and every circumstance connected with preserving health. It has also been treated by some of the most experienced and able surgeons in the navy; and there is nothing peculiar to the soil surrounding the ports of the Channel where it has appeared.[1]

Dr. Trotter has given additional observations upon the Malignant Ulcer, in the third volume of his "Medicina Nautica": —

Additional observations by Dr. Trotter on the malignant ulcer of the British navy.

"The appearance of this ulcer is new in the Channel, and from what I am able to collect, was not known in any ship in the home-seas before the present war. It has, however, become a formidable disease, and has so little yielded to particular modes of treatment, that we have still to lament its ravages, and to confess that we are ignorant of its certain remedies. In the West and East Indies, this, or an ulcer very nearly allied to it, was frequently observed in ships during the last and former wars. But Dr. Gillespie is the first who had given any accurate account of it, as he met with it in some of the hospitals in the West Indies. In the ships of the Mediterranean it has been very common; but little attention has been directed to the investigation of its causes, so that its history on that station is almost lost.

[1] *Medicina Nautica; an Essay on the Diseases of Seamen*, in three volumes, by Thomas Trotter, M. D., late physician to His Majesty's Fleet, etc., vol. ii. pp. 169-196.

"In the summer of 1799 the malignant ulcer made its appearance on board the *Téméraire*, with all the characteristic symptoms and virulence which marked it in other ships. Every wound, abrasion of the cuticle, blistered part, scald or burn, passed rapidly through the various stages of inflammation, gangrene, and sphacelus, in a few days leaving the bones almost bare from the separation of immense sloughs. The tendency of the bone to caries, after inflammation in this disease, has been more frequent than in any other species of ulcer. It has been chiefly observed in the tibia, but also in some of the bones of the face. These bones being superficial, the periosteum is from contiguity affected by inflammation, and with it also the blood-vessels which enter the bone partake of the affection, slough, and leave a portion of the osseous substance without the supply of blood; and thus the external lamina become carious, decay, and exfoliate. This has, in many cases, rendered the cure tedious and painful, and many have sunk under the long confinement. The *Téméraire* had been lately commissioned when the ulcers first appeared: the crew was composed of men that had just returned from foreign stations, and from having some years' wages to receive, they plunged as usual into all the excesses of drinking. . . . .

"In the *San Josef*, fitted at Plymouth in January, 1801, to bear the flag of Lord Nelson, this ulcer soon began to make its appearance. In February, Mr. Walker mentions four cases being sent to the hospital. Four were sent to the hospital with very ill-conditioned ulcers, and those remaining on board (seven) have not the most favorable appearance. In the succeeding month he remarks: 'The number of ulcers has increased (13); two were sent to the hospital; again, others nearly cicatrized have broken out afresh. This ulcer has all the appearance and symptoms of the malignant ulcer that has of late infested the Channel fleet. It does not seem quite so rapid in its progress, nor are the symptoms so violent.' In April the list of ulcers still increased (23). 'Our ulcers increase and begin to assume a formidable appearance. Every bruise, wound, or scald, in the course of a few days put on the appearance of the malignant ulcer, and go through its different stages, attended with little or no fever. It seems to be highly contagious. The worst cases I have put by themselves. I cannot trace its introduction into the ship!' . . . .

"A change took place in the month of May, between the surgeons of the *Neptune* and *San Josef*, and Dr. Felix describes the situation of his sick-berth in the following manner: 'You will perceive that I have no great reason to congratulate myself on the exchange, at least for the present. I found not less than forty ulcers on board the *San Josef*, of the most unfavorable, if not of the most malignant nature that ever came under my observation. Upon inquiry of the mates, I found that a disposition to this sore had prevailed for several months; that the most trivial hurt on the extremities, or even the smallest wound, be-

came, in forty-eight hours, an ulcer of the worst description, and that no means could stop its spreading and sloughing for several days. Latterly a contusion or blow on the leg, etc., produced the same appearance, and I observed in one man, of the name of Henderson, an ulcer that had followed a blow on the ear, that was attended with a very slight wound. In two men the entire muscles of the leg sphacelated, and the disposition to spread still manifest; in another man the foot was in the same condition; in two or three the tibia bare and exfoliating, and in many the same process was to be expected.'

"Mr. Jarvis, surgeon of the *Indefatigable*, in a letter dated the 5th of July, 1801, observes, that after the celebrated battle of the Nile, several malignant ulcers made their appearance in the *Culloden*, of which ship he was then surgeon, that generally arose from very slight scratches, scalds, or wounds, and some from boils or small pimples, all of which resisted every method of treatment that he put in practice. If the pimple or boil were seated on the lower extremity, it was very inert and slow in suppurating, although cataplasms, etc., were applied, and after the dead cellular substance or core appeared through the cuticle, several days elapsed before the slough was separated. When the slough was thrown off, the edges in some became ragged, in others quite callous and horny, and when this last separated, the ulcer was much extended in size. Absorption took place from several of the ulcers, and produced considerable turgescence of the lymphatic vessels. In some cases, when the ulcer began to heal, another boil appeared in its vicinity, which sometimes suppurated and formed a second ulcer more malignant than the first, but the boil more frequently disappeared, the original ulcer began to discharge again, and pass through all its stages with symptoms of augmented violence. He says it appeared to him that the system was struggling to be freed from something highly noxious and hostile to its healthy action, and that he at last left the treatment to nature.

"When the ulcers attacked the knee or other parts thinly covered with cellular substance, the slough was generally so deep as to destroy part of a tendon or muscle, and to injure their motion. One patient had an ulcer seated between the tendons of the ham, which was at length healed, but the tendons were contracted, and the motion of the joint entirely lost. Another had a similar ulcer, which was so irritable and painful that he could not suffer it to be dressed; he became dyspeptic; his stomach rejected everything he took, and, after lingering a month in the utmost agony, he died. Another patient was attacked with inflammation on his shin, which proceeded to suppuration in spite of leeches, cathartics, etc. When the abscess was opened, the tibia and fibula were found to be carious, and in a few days the man became weak and much emaciated. Soon afterwards a large abscess formed above the knee, and it is extraordinary that no previous pain was felt, nor inflammation observed in the part. It had been hinted to him a few days before, that

it would probably be necessary to resort to amputation, which he was unwilling to comply with, but when he saw the abscess he solicited to have the operation performed, — a circumstance that created some embarrassment in Mr. Jarvis, for the abscess ran so far up the thigh that the stump must necessarily be very short. As his strength was however declining rapidly, the operation was resolved on and performed above the seat of the abscess. The muscles were found to be so flaccid as scarcely to resist the knife. The stump was healing, and the patient recovering his strength and spirits, when he was sent to the Naval Hospital at Port Mahon, where he was soon cured."

The following observations were furnished Dr. Trotter by Mr. McArthur, whose communication is dated His Majesty's ship *Bellisle*, in Torbay, 15th December, 1801. These facts concerning "the Malignant Ulcer" were collected by Mr. McArthur whilst he was surgeon of His Majesty's ship *Ganges*, in the year 1797: —

Observations of Mr. McArthur on the malignant ulcer on board the ship *Ganges*.

"She had been employed in the West Indies several years at the beginning of the war, and had arrived from thence at Spithead, in October, 1796. Between this time and my appointment to her, the 1st of June, 1797, about two hundred men had been sent to the hospital; near two thirds of these were ulcers. On the 4th of June we sailed to the North Sea to join Admiral Duncan's squadron, and continued off the Texel, until a few days before the 11th of October. I soon found a strong disposition to ulcers on board, the most trifling hurts in a few days degenerating into extensive sores. A small scratch that at the last dressing discharged healthy pus, and apparently had every disposition to heal, at the next was found painful, the discharge dark and streaked with blood, its edges livid, and the surrounding integuments inflamed. From this beginning, a gangrene extended with great rapidity, occupying, if situated on the legs or thighs, etc., in three or four days from five to ten or twelve inches in circumference. When the diseased parts were thrown off, the ulcer would soon fill with healthy granulations, and would contract considerably; or was nearly cicatrized over, when a small black speck, not larger than the head of a pin, would appear upon its edge; from this point a second gangrene commenced, and extended as rapidly as the former. This was their most common beginning and progress; but frequently, instead of a sphacelus being formed, the new granulations, the lips of the wounds, the surface of burns, blisters, etc., seemed to be converted into a kind of thick adhesive pus, which adhered firmly to the parts underneath; these did not extend so rapidly as the former, but the diseased action continued much longer. In whichever way the ulcers extended, they were very painful, the discharge considerably bloody and offensive; the patients were restless, complained of headache and thirst; the skin

was hot and dry, and the pulse, for the most part, full. These febrile symptoms disappeared as the diseased parts were thrown off. The first gangrene, except when situated on the fingers or toes, or the cicatrice of old ulcers, seldom destroyed more than the integuments; the next affected the muscles, and, if situated on the tibia or bones thinly covered, destroyed the periosteum, leaving a considerable portion of the bone denuded and carious. Every subsequent mortification affected the muscles more and more; in one instance the gastrocnemius was completely destroyed. This ulcer first appeared on board in the West Indies about the beginning of 1795, and from every information I received, it did not deviate from its original character until it disappeared in January, 1798. It is somewhat singular that the marines and landsmen who were sent on board to complete her complement of men, a considerable time after her arrival in England, were as susceptible to the same kind of sore as the old part of the ship's company, and men in good health, and to all appearance of a good habit of body, as those who had been previously reduced by diseases. It was also particularly remarked, that the men who were employed as nurses, and almost every person who was put into the sick-bays was soon afflicted with ulcers, and that some men who had suffered amputations, and had been permitted to remain in the sick-bays where the ulcers were, did not recover so well as others who had been separated, and put in a separate berth under the half-deck. I did not observe any symptoms of scurvy among the men afflicted with ulcers, excepting sometimes a wasting of the gums, which I attributed more to a want of cleanliness and the use of tobacco than to a scorbutic diathesis. In the treatment of these ulcers, I thought that bark and wine given during the progress of the gangrene, augmented the local inflammation and constitutional affection, but the moment the sphacelus began to separate, and the febrile symptoms subside, they were very serviceable in supporting the strength under sometimes an excessive discharge; nor was opium in the earlier stages of so much use in alleviating pain as might have been expected.

Warm poultices seemed to accelerate the gangrene, but they also hastened the separation of the slough; on the contrary cold solution of the acetate of lead constantly applied to the sore and surrounding parts retarded the gangrene, but the separation of the sphacelus was more tedious. The nitrous fume was applied to ulcers in every stage, but particularly to those that continued indolent after the separation of the mortified parts, or such as were covered with the thick adhesive pus, but I did not observe any good effect from it; it was, however, of considerable use in destroying the bad smell in the sick-berth while the ulcers were dressing. I thought the hydrarg.-nitrat. rub. prevented in some instances the ulcers from extending after they had put on the unhealthy appearance; and latterly, in consequence of reading Dr. Rollo's account of the ulcer that prevailed at the Artillery Hospital,

the black speck was destroyed with the argentum nitratum. In some cases it was successful, in others it had no effect. As the cold weather set in, the disposition to ulcers seemed stronger. Towards the latter end of December, being completely disappointed in every hope I had of curing them on board, and perplexed at their daily increase, I determined upon sending all the ulcers on shore to the hospital at Yarmouth, and at the same time applied to the Commissioners for Sick and Hurt for a vegetable diet for the ship's company. The Board, in the most liberal manner, directed Captain McDowall to cause to be purchased vegetables, not exceeding four pence a man per diem, but I believe they did not amount to more than three half-pence. Twelve dozen cabbages, five bags turnips, three ditto carrots, and four bushels of onions, were daily put in their broth, or distributed in the messes. The vegetable diet commenced, and the remaining ulcers were sent on shore between the 25th and 31st of December, and by the middle of January not a vestige of the ulcer remained on board. There were indeed several ulcers upon the sick list, but they had not the smallest resemblance to the ulcers that had made such ravages on board during the last three years. Between the 10th January, 1798, and November following, only one ulcer was sent to the hospital, but during the preceding seven months there was no less than seventy. I shall make no remark upon this fact further than observing, that although the vegetable diet would seem to have destroyed the disposition to ulcers, yet these ulcers did not at all resemble the scorbutic ulcer, but would alternately heal and extend after a scorbutic diathesis must have been removed by the use of lemon-juice and vegetables, even if such a diathesis had originally existed. I also thought the removal of the ulcers from the ship was of considerable utility, as the air of a sick-berth when there are ten or twelve ulcers, some of them in a state of gangrene, must be vitiated. Would men breathing this contaminated atmosphere acquire a similar habit with those already afflicted with ulcers? And would they not in consequence be susceptible to the same kind of sore?"[1]

The following is the account given by Mr. McDowall of this disease as it prevailed in the *Royal George*, in the month of January, 1802: —

Mr. McDowall on the malignant ulcer on the *Royal George*.

"Since our leaving Cawsand Bay we have been severely afflicted with several sores of considerable magnitude; whether they originated from contusions, wounds, scalds, chilblains, or blistered parts, etc., they very soon assumed symptoms of very great malignity, and with very few exceptions they all observe the same degenerate tendency, notwithstanding we have paid the greatest attention in dressing to obviate the pending evil; the disease pursues such a magisterial course, ending only in a vast destruction of organized

[1] *Medicina Nautica*, vol. iii. pp. 467–499.

parts. It appears to be a disease of very high excitement; but I am doubtful whether it be contagious, although it appears to be endemic at present in this ship. I have distinctly marked several sores in our sick-berth at the same time with some of the worst cases under our consideration, without ever being affected by them. Also a patient has complained to me of a small pimple, arising from a hurt, and when it was impossible to trace his exposure to the infection of any sore; yet so rebellious would the case prove that in the course of a day or two it would rapidly pass through the several stages of inflammation, gangrene, and sphacelus; and all our art has as yet devised, is quite inadequate to arrest its progress in the destruction, to a considerable extent, of the adjacent integuments, muscles, membranes, and even the bones, also, in some instances have not escaped the general devastation. We cannot impute anything of a scorbutic taint to our people; they are now living (and have been for months back) on more than two thirds of fresh beef, beer, and plentifully supplied with vegetables. Neither is there anything in it of a scorbutic nature."[1]

Doctor Robert Jackson, in his "Sketch of the History and Cure of Febrile Diseases," expresses the opinion that the malignant ulcer, which is so common in the West Indies, whether mild and disposed to assume the healing process, or gangrenous and rapidly destructive of muscles and bones and of life itself, is connected in its origin with the general cause which produces fever, either endemic or contagious.

Dr. Robert Jackson referred the origin of malignant ulcer of the West Indies to the same causes which produce fever.

"The circumstances which were observed in the 3d regiment of foot in 1794, and the occurrences which took place in the force which was collected on Spike Island in autumn 1795, impressed the author with the idea that the ulcerative form of disease, as here described, is radically connected with the cause of contagious fever. The history of health among the troops in St. Domingo brought evidence, satisfactory to himself at least, that the connection extended to the endemic; the experience which he has since had in different scenes of service confirms me in the opinion then formed. The febrile, the dysenteric, and ulcerative forms of disease, are ordinarily the three prominent columns on the sick returns of military hospitals. Sometimes the one predominates, sometimes the other; but fluctuate as they may, a balance is generally observed between them so poised and so adjusted as to furnish a valid argument that they ultimately have their dependence on the same general cause, modified by circumstances often so minute or so complicated as to escape detection. . . . .

"The medical history of armies shows that the gangrenous action sometimes arises suddenly and unexpectedly, and spreads so rapidly

[1] *Medicina Nautica*, vol. iii. pp. 501, 502.

that it can scarcely be supposed to have its origin from actual contact of person, much less from contagious matter applied to a suppurating surface; it appears, in fact, to be infectious by imitation of what may be supposed to fall within the sphere of vision."[1]

We have in the second chapter of this work examined the views of Baron Larrey on "Traumatic Gangrene;" we will now give some extracts from his "Surgical Memoirs," which contain facts bearing upon the present discussion.

Observations of Baron Larrey on hospital gangrene in the French army under Napoleon.

"On the 28th, Bonaparte arrived before El Arich with his headquarters and the park of artillery. We besieged the fort, drew trenches round it, and battered it in breach. The besieged agreed to capitulate, and after two days' negotiation they demanded permission to retire with the honors of war, which was acceded to on our part.

"Some of our men were severely wounded in this siege, and were seized with tetanus; they died, notwithstanding every possible attention was paid to them. As the rain continued all the time we remained before the fort, it was impossible to preserve them from the moisture to which they were a long time exposed.

"As soon as the fort surrendered, the general ordered me to visit its interior, and to take such measures as I thought proper to purify its apartments and clean them of infection. An officer of the *etât major*, who had thirty Turkish prisoners at his disposal, was to act in concert with me in the execution of this measure. I immediately examined whether any wounded and sick had been left by the besieged, and discovered fifteen in subterranean caverns, deprived of light and air, laid on mats that were almost rotten, without bedclothes, and covered with vermin. These unfortunate men had received no medical aid; in almost every instance their wounds were without dressings, gangrenous, and filled with animalculæ. Some of them presented all the symptoms of malignant fever; one of them had a pestilential bubo in the right side of the groin, and a carbuncle on the right leg. . . . .

"At break of day the signal to engage was given on both sides, the enemy having also resolved to attack us the same day. The first shock was very severe, but success was never doubtful. A most complete victory on our part was the result of this brilliant and memorable battle, called the Battle of the Three Emperors, or the Battle of Austerlitz. The enemy lost more than forty stand of colors or standards, more than five hundred pieces of cannon, twenty generals, and thirty thousand men prisoners. Between ten and twelve thousand were killed on the field of battle, or drowned in the lakes, besides a great number of wounded that we successively collected and had transported to Brunn. . . . We had scarcely collected the wounded of the French and

[1] *Medicina Nautica*, vol. iii. pp. 190–196.

Russian armies, the number of whom was considerable, when an epidemic disease appeared among them which we recognized as a malig nant, nervous, and putrid hospital fever (adynamia-ataxick), or contagious typhus of the old nosologists. It attacked with heavy pains of the head and irregular chills, especially of the extremities. These chills were succeeded by a transient burning heat.

"The wounds in which suppuration first diminished were affected with the hospital putrefaction,[1] which advanced in the most rapid manner. The pains of the head, the external heat, and anxiety, increased; the pulse, which at first was small and slow, became more quick and irregular, and the urine was turbid and yellow. In some cases costiveness attended, but generally a diarrhœa was one of the first symptoms of the disease. The ear and the eyes became exquisitely sensitive; the functions of the muscular system were disordered; a tremor of the limbs, subsultus tendinum, and delirium commonly attacked the patient at the end of the first stage.

"To the above symptoms succeeded pains of the epigastric region, wandering colic pains, vomiting preceded and attended by singultus, retention or suppression of urine, clammy and colliquative sweats, an increase of a dysenteric discharge of fetid black blood, and finally hemorrhage of the nose. The tongue was black in the centre, and dry and red on its edges; the gums and teeth became covered with black glutinous sordes. The patient sunk into a state of drowsiness and general insensibility, made involuntary motions which, on account of the prostration of strength, were but of short duration. The pulse decreased in volume as it increased in quickness. The features of the face became surprisingly altered, and indicated the change of the organic functions. Whenever I saw this symptom in the last stage I predicted a fatal issue.

"These symptoms generally increased while the disease was passing from the second to the third stage. The pulse intermitted, exacerbations or paroxysms occurred once, or even twice, in the twenty-four hours. During the paroxysms, the delirium in some cases became more furious, and was often attended with convulsions. Turbid or diminished secretion of urine were fatal symptoms, and if it suddenly became clear and limpid, the danger was most imminent; the abdomen then was inflated, the internal spasm increased, and the singultus returned. The patient lost all his intellectual faculties, fell into extreme debility, and soon sunk. When the disease terminated in this manner the patient rarely survived the ninth day, but generally died on the fifth or seventh. In this last stage the wounds assumed a real gangrenous appearance, and emitted a very fetid odor. The effluvia produced by the purulent

1 When this affection takes place, the suppuration is of a grayish lead color, thick and glutinous, and emits a fetid odor; the edges of the wound puff up and become black. The heat and sensibility of the parts affected are destroyed.

secretion or exhalation of these ulcers was very infectious, and all that were near those sick of this epidemic were in great danger, as were also the physicians who visited them. All who lay in these wards were soon attacked by the same symptoms. The disease spread further and further, infected the hospitals, and finally the houses in their vicinity, either by the communication of persons with the sick, or the transmission of air by the south wind, especially when it had but a short space to traverse. These winds, as I remarked in speaking of the plague, favor the production of almost all ataxick diseases.

"The transportation of the sick also extended the contagion, which increased to such a degree that the hospital of the line lost one fourth of their wounded. They who had fractures of the limbs, and especially of the inferior extremities, were its first victims. Because, in the first place, these wounds affected the membranes of the bones, the ligaments, and the aponeuroses, which receive their sensibility or life from the trisplanchnic nerve, and thus the power or life of the nutritive system is impaired. And secondly, because adynamia more readily follows the debility of these functions produced by this sympathetic affection. And finally, because the permanent inaction to which the wounded are obliged to submit subjects them continually to the action of the infected atmosphere of the wards, and renders them more obnoxious to this disease. These facts support the argument adduced in my memoir on amputation to prove the necessity of taking off the limb on the field of battle, when we cannot expect to cure the fracture by the usual mode of treatment. The hospitals in which those who had fevers were deposited were soon crowded, and the mortality was increased in proportion. The epidemic also broke out among the Russian prisoners who had been from necessity crowded in great numbers into the churches and other large buildings; finally it soon spread among the inhabitants, and extended itself along the whole line, and even into France, in consequence of the transportation of prisoners and of the sick of both nations. The disease was irregular in its progress when it attacked those who had fractures of the thigh. It ran its course with great rapidity, and nothing relieved the symptoms. I saw several superior officers who died with such wounds very suddenly after I had entertained strong hopes of their recovery. When the wounds were less severe, the disease was milder, and in its progress less rapid. Many of the sick recovered by the use of suitable remedies. . . . .

"This epidemic rarely appeared among the wounded guards who were placed in the hospital La Charité, which was distant from the other hospitals and from the populous parts of the city. It was well lighted, well-aired, and kept perfectly clean.

"The causes of this epidemic may be referred to the fatigue and privations which the troops of both nations had undergone; to the severity and vicissitudes of the season; to the crowding together the

prisoners, the wounded, and the sick of both armies; to the bad diet, and their confinement after the most fatiguing and rapid marches."

Doctor Macleod, in his "Notes on the Surgery of the War in the Crimea," states that —

"The French suffered most dreadfully from hospital gangrene in its worst form. The system they pursued of removing their wounded and operated cases from the camp to Constantinople at a very early date, the pernicious character of the transit, the crowding of their ships and hospitals, all tended to produce the disease, and to render it fatal when produced. Many of their cases commenced in camp, but the majority arose in the hospitals on the Bosphorus, where the disease raged rampant. In the hospitals of the south of France it also prevailed, and from what M. Lallour, surgeon to the *Euphrate* transport, tells us in his paper on the subject, it must have committed great ravages in their ships, from one of which, he says, sixty bodies were thrown over during the short passage of thirty-eight hours to the Bosphorus. With them the disease was the true 'contagious gangrene,' and attacked not only open wounds but cicatrices and almost every stump in their hospitals. They employed the actual cautery, after the manner of Delpech and Pouteau, with apparent success, to arrest it. The perchlorate of iron, charcoal, the tincture of iodine, lemon-juice, etc., they employed as adjuvants. In both the French and Russian hospitals, gangrene was often combined with typhus, and in such cases the mortality was fearful."

Dr. Macleod on the cause of hospital gangrene amongst the French in the Crimea.

All these facts show that the origin of hospital gangrene is preeminently due to over-crowding.

3. *The contact of the gangrenous matter with diseased and wounded surfaces, as in using unclean sponges, bandages, wash-bowls, and surgical instruments.*

No doubt appears to exist in the minds of many surgeons that hospital gangrene may be readily communicated by actual contact of the matter from one wound to another, and that the matter may be inoculated into the healthy subject, just as in the case of the matter of small-pox, and produce a poisoned wound exactly similar to the one from which the matter was taken.

3. Cause of hospital gangrene the contact of gangrenous matter with diseased and wounded surfaces.

This question can be settled only by direct observation and experiment. In the first chapter of this work the author has propounded several inquiries upon the mode of origin and nature of hospital gangrene under the divisions "D. Is hospital gangrene contagious?" "E. If hospital gangrene be contagious, how is it transmitted, — through the atmosphere, or by direct contact and

inoculation?" "F. What are the essential conditions and causes of hospital gangrene?"

A number of the questions contained under these general divisions have been already discussed, and we will now confine ourselves chiefly to the discussion of the following questions:—

(*a.*) Can hospital gangrene be propagated by direct contact and inoculation?

The question as to the possibility of propagating hospital gangrene definitely settled in the affirmative. Illustrative observations.

As far as my observation extends, this question is no longer an unsettled one. A number of cases have come under my notice where nurses and surgeons have accidentally wounded their hands in dressing gangrenous wounds, or in operating with spiculæ of necrosed bones, in which the disease was immediately reproduced after the inoculation of the matter. The severity of such cases, as a general rule, appeared to depend chiefly upon the state of the constitution, and the extent to which the patient had been exposed to the foul emanations of the hospital, and especially of the gangrenous wounds. Case VII.,[1] which we have already presented in the third chapter of this work, illustrated not only the direct inoculation and reproduction of hospital gangrene on two distinct occasions in the same individual, but also afforded a clear demonstration that the continued residence in the infected atmosphere, and the constant attention upon the gangrenous wounds, gradually poisoned the system to such an extent that in the second attack the local treatment did not arrest the disease. Near one half the nurses attending upon the cases of hospital gangrene in the first ward of the Empire Hospital took the disease in their hands or in their feet. Five out of twelve nurses contracted the disease. In four of these cases the disease appeared to be the result of direct inoculation. In the other,[2] a small boil appeared on the tendo Achillis twenty days after his employment as nurse. This soldier did not dress the wound, but simply waited on the sick, handing water around, and assisted in erecting the tents. He did not sleep with the sick, but on the outer line of tents with the kitchen, etc. He wore shoes and stockings, and it was not possible to ascertain whether or not there had been any direct application of the gangrenous matter. In five days the small boil enlarged to three inches in diameter. Nitric acid was then applied and arrested the disease, and this nurse was sent home eleven days after. At this time the surface of the ulcer presented a florid, granulating surface, with a discharge of pus.

[1] W. J. Black, Company G, Lee's Invalid Battalion.

[2] Case of E. Morgan, Company C, 10th Regiment, Mississippi Vols.

In many of the patients treated for hospital gangrene in this hospital, the disease recurred after its removal, and in several of the fatal cases death was the result of a second or third attack. Upon careful examination I was convinced that the reappearance of the disease in these cases was not entirely due to the condition of the constitution of the patient, nor to the infected atmosphere of the hospital and the exhalations from the neighboring cases of gangrene (fresh cases being brought in continually from other hospitals in Macon and Vineville), but chiefly to the fact that there was no division of labor amongst the nurses, and the utensils were not sufficient to supply each patient with his own basin. The rags also were frequently washed after having been used upon bad gangrene cases, and then employed indiscriminately upon the convalescent and gangrene cases. When nurses infected with the foul odor of the worst gangrene cases went directly to a healthy granulating wound, and with the same fingers and instruments which but a moment before were employed in cleaning and pulling away gangrenous sloughs, the recurrence of the disease was almost inevitable. In many extensive and granulating wounds a small gangrenous spot would appear, and in a night spread over considerable portions of the raw surface.

This subject may be still further illustrated by the following cases: —

Case LI. Illustrating the contagious nature of hospital gangrene.

Case LI.—Thomas Benton Childers, Company C, 1st Regiment Alabama Vols., Quarel's Brigade, Polk's Corps. Age twenty-one; height, five feet eight inches. Native of West Alabama. Had been in Confederate service since 15th of July, 1862. Entered the City Hall General Hospital, in Macon, Ga., 14th of July, 1864, with dysentery. After recovering was appointed to nurse the gangrene cases. The patient had been suffering with an eruption upon the instep of both feet. The weather was warm, and at night he would frequently nurse the patients in his bare feet; and as the eruption occasioned considerable itching, after nursing the gangrene, the patient would scratch his feet. In the course of two weeks after he had commenced nursing, the gangrene appeared on the instep of both feet (September 2), and spread with considerable rapidity. On the 16th of September this patient was transferred to the Empire Hospital at Vineville.

After the inoculation of the gangrenous matter the abrased surface was very painful, with a dark-colored, purplish areola around, and the disease progressed rapidly. The local application of nitric acid together with the internal administration of tinct. muriate of iron and quinine, arrested the spread of the gangrene in various parts of the wounds.

October 6. — Denuded surface of instep of left foot about two inches in diameter; gangrene apparently removed; granulations springing up; the surface is, however, paler than in healthy wounds, and the pus secreted is of a yellowish, greenish color, and tenacious character, and adheres quite firmly to the granulating surface.

The instep of the right foot is extensively denuded, the tendons and the periosteum of the bones being exposed. Between the big toe and the second toe, the gangrene has invaded the structures to a great extent, exposing the tendons and periosteum. The gangrene appears to be still progressing around and under these bones. Also upon the superior portion of the wound the gangrene is burrowing upwards towards the ankle joint. This ulcer is about four and a half inches in diameter, and the surface in those portions from which the gangrene has been removed, presents pale, unhealthy granulations, coated with thick, tenacious, greenish yellow pus, which adheres to the surface. In those parts where the gangrene is still progressing, the color is of a greenish gray.

The constitutional symptoms in this case are well marked: rapid, feeble pulse, febrile excitement in the afternoons and evenings, loss of appetite, progressive loss of flesh, with depressed spirits. The granulating surface appeared to possess an exquisite sensibility. The application of nitric acid caused the most intense pain, and the patient, during its action and the dressing of the ulcers, cries like a child.

October 18. — Pale, emaciated, and in an exceedingly nervous and excitable state. Cries like a child whenever his feet are touched, or whenever he sees the nurse passing with the bottle of nitric acid. The play of his features at such times is very marked, and expresses great dejection, fear, and pain. No appetite. The ulcer upon the left foot is stationary; whilst that on the right slowly enlarges, especially along the upper and lower borders. Granulations, pale and unhealthy. Surface of both ulcers still covered with the tenacious, light green, and greenish yellow fetid pus.

Examination of Urine. — Amount of urine collected during the past twenty-four hours (October 17, 12 M., to October 18, 12 M.), 380 CC. = grains 6,099. This is not the entire amount, as the patient lost a portion during the action on his bowels. The urinary excretion has, however, decreased to a marked extent. The patient is much reduced, and eats nothing. Urine of a deep red color, and strong acid reaction. The acid reaction remained apparently unchanged for more than seventy-two hours, and during this period no deposit fell. Under the microscope, a few crystals of the oxalate of lime (octahedral) were discovered. After several days the urine became alkaline, and prismatic crystals of triple phosphate were thrown down, in conjunction with the octahedral crystals of oxalate of lime.

Specific gravity of urine, 1,016.5.

ANALYSIS OF URINE, NO. 50.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours.	6,099.00	
Urea	169.70	27.98
Uric acid	6.08	0.99
Free acid	5.26	0.86
Phosphoric acid	2.80	0.45
Equivalent of phosphorus in phosphoric acid	1.22	0.20
Sulphuric acid	8.85	1.28
Equivalent of sulphur in sulphuric acid	3.54	0.57
Chloride of sodium	2.92	0.47
Equivalent of chlorine in chloride of sodium	1.76	0.28

The treatment at the present time consists of turpentine emulsion, with the addition of three grains of quinine to each dose. Whiskey f℥ij. three times a day. Half diet.

October 19. — Twelve o'clock M. Appetite poor; eats little or nothing. Has had two or three rather thin operations during the past twenty-four hours. Nervous and excitable.

The deep excavation between the bones of the left big toe and of the second toe discharges a thin, fetid pus. The granulating surface in other portions is still covered with a thick, tenacious, light-green and yellow pus.

The following drawing was executed on this day. (See Plate No. XXXIX.[1])

Examination of Urine. — Amount of urine collected during the past twenty-four hours, 670 CC. = grains 10,681.87. The patient affirms that the urine was collected with the greatest care, and that this is the entire amount. Orange-red color. Specific gravity, 1,012.5.

ANALYSIS OF URINE, NO. 51.

Elements.	Urine collected during 24 hours, contained grains	1,000 parts of urine contained
Amount of urine collected during twenty-four hours.	10,681.87	
Urea	211.51	19.80
Uric acid	5.03	0.47
Free acid (twenty-four hours)	5.15	0.48
Phosphoric acid	2.03	0.19
Equivalent of phosphorus in phosphoric acid	0.98	0.09
Sulphuric acid	16.01	1.49
Equivalent of sulphur in sulphuric acid	6.40	0.05
Chloride of sodium	2.06	0.19
Equivalent of chlorine in chloride of sodium	1.24	0.11

The solution of chloride of iron gave scarcely any indication of phosphoric acid in the urine, and when a solution of the sulphate of

[1] Omitted.

magnesia in chloride of ammonium was added, only a slight deposit of the phosphate of magnesia was thrown down.

Forty-eight hours after the collection of the urine, it became slightly turbid from the formation of a deposit of granular urates, etc., beautiful, large, well-formed prismatic crystals of triple phosphate. It is important to note that although the phosphates were in so small amount, still well-formed crystals of the phosphates were formed, which sparkled like grains of shining silver when the urine was held in the sunlight. This observation illustrates the care which should be exercised in deciding upon the amount of phosphoric acid present in any sample of urine from the size and number of the crystals of triple phosphate. Reaction of the urine at this time (forty-eight hours after its passage), alkaline.

This case improved not at all, and appeared to remain stationary, or rather slowly losing flesh and strength.

October 27. — No improvement in local or constitutional symptoms, and patient transferred to private quarters.

Case LII. Illustrating the contagious nature of hospital gangrene.

CASE LII. Mrs. Jackson, wife of private R. L. Jackson, Company C, 25th Regiment Georgia Vols., whose case has been already detailed in the fifth chapter (Case XXVI.). This lady came down to Augusta in the month of October, 1863, to nurse her husband, whose arm had been amputated in consequence of a gunshot wound received at the battle of Chickamauga. In coming down to Augusta, this woman wore a new pair of shoes, which blistered her left foot, upon the outer side, just above the hollow. After entering the hospital she walked about in her bare feet, nursing her husband. Gangrene of a severe form appeared, and spread rapidly, involving the bones of the tarsus. As the floor, especially just under the gangrenous stump of her husband, contained more or less gangrenous matter, it is highly probable that the matter was introduced directly into the foot through the blistered surface.

The spread of the gangrene was rapid, and the constitutional symptoms well marked: great nervousness, periodic febrile excitement, feeble, rapid pulse, and dejected countenance, great suffering and no power to bear pain, and a dusky, sallow hue.

Case LIII. Illustrating the contagious nature of hospital gangrene.

CASE LIII. The report of this case was furnished me by Assistant-Surgeon Anderson of the Ocmulgee Hospital, at Macon.

Mrs. V. Oneal, age seventeen, wife of a conscript; detailed nurse in Ward No. 8; came to see her husband on the 20th of October. The same evening Dr. Anderson removed an encysted tumor, about one inch in diameter, from the dorsum of the right wrist joint, and adjusted the wound carefully with a view to as speedy union as possible. She visited the ward daily, and remained with her husband a greater part of the time, who was one of the wound dressers of the ward. He dressed his wife's arm. On the 24th of Oc-

tober Dr. Anderson was called to see the woman, and found the wound phagedænic, presenting a circular, sloughing surface of about one and a half inches in diameter; dark gray, or grayish color. Hand and wrist very painful, and very much swollen. Three or four whitish-looking spots were to be observed in the vicinity of the ulcer, the largest about eight lines in diameter; these were for the most part above, on the upper side of the wound. These proved to be superficial effusions of apparently healthy pus, being rather limpid, and external to the cutis vera. The patient was not allowed to visit the ward any more, and was treated with nitric acid as a local remedy.

October 27. — Considerable constitutional disturbance. Pulse 130, and thread-like. Arm very much swollen. (Quinia sulph., grains viii., at six and nine A. M. every morning. Whiskey toddy every three hours during the day. Absolute quiet. Arm and hand supported in splint.)

October 29. — Decided improvement, both local and constitutional.

November 9. — Disease has entirely disappeared, and wound healing kindly.

This woman belonged to the humbler class; had been subjected to impoverished diet and hardship. She was in tolerable health at the time of the operation, but appeared to be in an exsanguineous condition, and was inclined to scrofula. This case illustrates the production of the disease by inoculation, or by direct contact of the gangrenous matter. Her husband being a nurse, and being exposed to the poisonous wounds of numerous patients, and dressing her wound at the same time, was most probably the medium of the communication of the gangrenous matter.

Several of the nurses and medical officers of the Ocmulgee Hospital contracted the disease during their attendance upon the gangrene cases. Two cases of gangrene in the fingers of nurses at this hospital, came under my direct observation.

Surgeon Battey, in charge of the Polk Hospital, Vineville, Georgia, showed me an ulcer upon his finger, which had been gangrenous, and which had arisen from the prick of a spicula of bone, during an operation upon a gangrenous limb.

In the Institute Hospital, in charge of Surgeon O'Keefe, I examined a gangrenous ulcer upon the leg of a soldier, who had contracted the disease whilst nursing and attending upon cases of gangrene. This soldier (J. H. McNight, Company C, 19th Louisiana Regiment) had a small scratch upon his leg, to which the gangrene was conveyed by his fingers, after washing and dressing gangrenous wounds.

The following communication from Surgeon Doughty furnishes several interesting facts bearing upon the discussion of the contagious nature of hospital gangrene: —

OFFICE SECOND GEORGIA HOSPITAL,
AUGUSTA, GA., *December* 14, 1863.

SURGEON JOSEPH JONES:—

SIR, — I have hesitated to reply to your communication of October 31, 1863, knowing that the proposed method of investigation contemplated only the admission of data obtained from systematic records of cases; opinions, however well matured, even when based upon the most extensive experience and observation, are of no value unless accompanied with the recorded facts from which they were derived. The manner in which most of the cases treated in military hospitals come before the observer, precludes the possibility of possessing, or rather preparing such records as may be said to possess strictly scientific value.

Observations of Surgeon Doughty upon the contagious nature of hospital gangrene.

If, however, an expression of opinion, supported by isolated facts, be not entirely inadmissible in the invited discussion of the numerous points suggested, I will venture to present such an one.

You ask, "Is hospital gangrene local or constitutional?" That it is not always constitutional in the primary signification of that word, is, I believe, true. In support of this, I may refer to the occasional inoculation of nurses and physicians whilst in attendance on this disease. Whilst on duty in Mississippi during the past summer, Assistant-Surgeon Ames exhibited to me the scar of an ulcer of this kind, the disease having been contracted by contact with the fluids and dressings used with cases of this character in an actively corroding condition; it was destroyed by the early and repeated application of a powerful escharotic.

Again, private Logan Luke, Company C, 1st Battalion Georgia Sharpshooters, was admitted August 10, 1863, into Walker's Division Hospital, at Lauderdale Springs, Mississippi, with hospital gangrene affecting the second and third phalanges of the little finger. Said soldier had been temporarily detailed for the care of the wounded, at the time of the second occupation of Jackson by the enemy, and contracted the disease by reason of an abrasion upon the finger. He was very careless, and whilst dressing those affected with hospital gangrene, kept the part in frequent contact with the fluids and dressings. The constitutional symptoms in this case ran high. On August 12, 1863, the finger, including the head of the metacarpal bone, was removed, the disease having extended by this time so far as to encroach upon the web of the fingers. Indeed, a part even of the inflamed areola was necessarily included in the flaps; the patient made a good recovery, without the recurrence of the disease in the stump. The constitutional symptoms promptly subsided after the operation, and the patient was placed under conditions favorable to his well doing.

Although the non-recurrence of the disease in this case does not prove that it may not have been constitutional (for constitutional diseases do not always promptly recur), yet, whether considered conjointly

with the probable and apparent mode of origin of the disease, it to say the least authorizes the presumption that hospital gangrene is not always constitutional.

I am not aware of the existence of any statistics showing the results of operations upon the disease classified as here indicated, *i. e.*, considering those as local which can be traced to inoculation, and those as constitutional which are apparently of spontaneous origin.

In regard to the relations of the local and constitutional disturbances, I am not prepared to offer anything definite. Recently, however, in several cases of relapses, the constitutional symptoms were not apparent, if indeed they existed at all; although the local ones were not of that markedly corroding nature which distinguished the original attacks.

Regretting that I have nothing of more value than the above to offer, I remain

Yours very respectfully,

WILLIAM H. DOUGHTY,
Surgeon in Charge.

I have performed experiments, to determine whether hospital gangrene can be inoculated into dogs. The following experiment will be sufficient to illustrate the results: —

Experiments upon animals with inoculation of matter of hospital gangrene.

Augusta, Georgia, November 7, 1863. — Subject of experiment, fine large pointer dog, in excellent condition; fat and healthy. Temperature of rectum, 39.7° C. (103.4° F.). At 12 M., I shaved the hair off the neck and shoulders of this dog, and making an incision two inches in length through the skin, inserted several pieces of the disorganized and bluish gray, green, and black masses, with the greenish gray fluid, from the thigh of the dead Federal prisoner whose case was detailed in the sixth chapter of this volume.[1] About half an ounce of gangrenous matter was thus introduced, and pushed down amongst the meshes of the cellular tissue, on the left side of the neck, and on the outer side of the left shoulder. The incision was then closed with the interrupted suture. The blood which flowed from the wound after the introduction of the gangrenous matter presented a dark, tar-like appearance. The dog appeared to suffer but little from the operation, and afterwards appeared quite lively.

November 8. — The dog remained during this day quiet. The wound appeared to itch, and he made repeated efforts to scratch it. Dark blood, together with softened particles of the gangrenous muscles, issued from between the sutures. The wound had the odor of gangrenous matter, evidently from the gangrenous matters still remaining in the tissues, and not from any decomposition of the structures. The

[1] See Case XI..

dog refused to eat food, and even meat, but drank water freely. The parts around the wound, and especially in the region of the left side of the neck, where the gangrenous matter was introduced, was much swollen. In walking, the dog moves the left shoulder with evident pain, and shrinks when the foot touches the ground.

November 9. — Healthy, yellow, thick pus issues from the wound in considerable quantities. The pus and the wound still emit a most disagreeable, gangrenous odor. The appetite of the dog continues poor, although he runs about quite lively when loosed. Temperature of rectum, 41.2° C. (106.1° F.). We observe a decided increase of temperature.

Eleven o'clock A. M. Pulse, 104 per minute. The rise of the thermometer is marked, and the degree of heat is equal to a warm fever in the human being. The muscles of the dog frequently tremble spasmodically, and the animal evidently feels badly. The wound still emits a most disagreeable, gangrenous odor. The swelling of the parts appeared evidently to be due in a measure to an accumulation of pus; when squeezed, about f℥iv. of thick, yellow, healthy-looking pus issued, which gave a slight acid reaction, and emitted the same gangrenous odor as the matter originally introduced.

November 10. — The appetite of the dog appears to be a little better, but is still quite poor. The pus from the wound appears to be changing in character, and presents a more watery and sanious appearance. The lips of the wound are much swollen.

November 11. — The sutures have torn out; the lips of the wound are much swollen and everted. The wound presents an unhealthy appearance, and a thin, fetid fluid mixed with some pus, issues from it. The dog shakes himself violently at intervals, and the thin, sanious fluid is thrown out with considerable force from the gaping mouth of the wound. This thin fluid is mixed with bubbles of air, and emits a disagreeable odor, and is very unlike the thick pus of the second and third days of the experiment. Temperature of rectum, 40° C. (104° F.).

November 12. — Wound presents much the same appearance, with dirty, brown, everted edges, and discharges the same fluid, mixed with bubbles of air. Dog still eats little or nothing, and is losing flesh rapidly.

November 13. — Slight improvement in the appearance of the wound, and in the appetite of the dog. Lips of the wound not so much swollen. The discharge of thin fluid still continues.

November 14. — Some pus discharged from the wound, the surface of which is much redder and more healthy. Dog livelier, and with a pretty good appetite. The animal is now reduced to a mere skeleton.

After this observation, the dog improved slowly, and the wound gradually healed.

It is evident that in the preceding experiment the gangrenous matter excited disturbances in the general system, as manifested in the elevation of temperature and the loss of appetite; and also that the local effects resembled to a certain extent those of hospital gangrene in the human subject. The differences observed may be due to the differences of inflammatory and gangrenous actions in the dog and man.

(*b.*) Can hospital gangrene be communicated to strong, healthy individuals by inoculation, the subjects of the experiments being removed entirely from the atmosphere of the hospital?

The question as to the possibility of communicating hospital gangrene to strong, healthy individuals by inoculation, the subjects of the experiments being removed entirely from the atmosphere of the hospital, definitely settled in the affirmative. Illustrative observations.

We are able to answer this question, also, in the affirmative.

Two stout negro women, in good health, were employed in washing the rags from the gangrenous wounds of the patients in the Empire Hospital. These women washed the rags and bedclothes in a small stream, over half a mile from the hospital, and at night slept about the same distance from the gangrene cases; and, as far as known, never came upon the hospital inclosure at all.

In the first case, the skin upon the inner parts of the wrists were abraded in washing the rags from the gangrenous wounds. Both these abrasions assumed, in the course of two or three days, a gangrenous appearance; and the woman was unable to continue her labors, on account of the pain and the spreading of the ulcers.

The ward-master, in response to her complaints about sore wrists, being ignorant of the cause, ordered the woman to tramp the gangrenous rags with her feet, in a tub of water. The gangrene attacked abrasions on the feet in like manner.

The other negro woman took the gangrene in the wrists in the same manner, after washing the gangrenous rags for a few days.

In both these cases, the constitutional symptoms were well marked.

Although the progress of the disease was arrested by the application of strong nitric acid, still the healing of the ulcers was very slow. At the end of two months, the ulcers still presented an unhealed, granulating surface. Assistant-Surgeon Powell, in charge of Ward No. 1, Empire Hospital, Vineville, communicated the preceding facts with reference to these two women.

A young negress, fourteen years of age, and in good health,

who was employed in picking up rags, emptying vessels, and in washing the faces of the patients about the Empire Hospital, accidentally stuck a pin from a gangrenous rag into the skin over the ball of the great toe. The pin merely inflicted a slight prick in the skin. The wound commenced to inflame almost immediately after, and in two or three days presented a gangrenous appearance. The ulcer spread rapidly, and destroyed the tissues, and exposed the bone in the course of six days.

These local changes were attended with fever, loss of appetite, and diarrhœa.

The healing of the wound, after its arrest with nitric acid, was very slow; and two months after the accident the ulcer was still upon the foot, and incapacitated the servant for labor. It is important to note that the gangrene was inoculated, and commenced its ravages, only four or five days after the patient commenced her attendance upon the sick, and that this patient had been scarcely at all exposed to the atmosphere of the hospital.

It is true that such cases did not equal in severity the following picture drawn by G. J. Guthrie, in his "Commentaries on the Surgery of the War in Portugal, Spain, France, and the Netherlands;" nevertheless, they presented all the characteristics of true hospital gangrene: —

Guthrie's description of hospital gangrene as it prevailed in the English army in Portugal, Spain, France, and the Netherlands.

"A wound attacked by hospital gangrene, in its most concentrated and active form, presents a horrible aspect after the first forty-eight hours. The whole surface has become of a dark-red color, of a ragged appearance, with blood partly coagulated, and apparently half putrid, adhering at every point. The edges are everted, the cuticle separating from half to three quarters of an inch around, with a concentric circle of inflammation extending an inch or two beyond it; the limb is usually swollen for some distance, of a shining white color, and not peculiarly sensible, except in spots, the whole of it being perhaps œdematous or pasty. The pain is burning, and unbearable in the part itself, whilst the extension of the disease, generally in a circular direction, may be marked from hour to hour; so that in from another twenty-four to forty-eight hours, nearly the whole of the calf of a leg, or the muscles of a buttock, or even of the wall of the abdomen, may disappear, leaving a deep, great hollow, or hiatus, of the most destructive character, exhaling a peculiar stench, which can never be mistaken, and spreading with a rapidity quite awful to contemplate. The great nerves and arteries appear to resist its influence longer than the muscular structures, but these at last yield; the largest nerves are destroyed, and the arteries give way, frequently closing the scene, after

repeated hemorrhages, by one which proves the last solace of the unfortunate sufferer. I have seen all the largest arteries of the extremities give way in succession, and until the progress of the disease was arrested by proper means, the application of a ligature was useless. The joints offer little resistance, the capsular and synovial membranes are soon invaded, and the ends of the bones laid bare.

"The extension of this disease is in the first instance through the medium of the cellular structure of the body. The skin is undermined, and falls in; or a painful red and soon black patch or spot is perceived at some distance from the original mischief, preparatory to the whole becoming one mass of putridity, whilst the sufferings of the patient are extreme. A complaint of this kind cannot long be local, even if a local origin be admitted; the accompanying fever is usually dependent on the previous state and general constitution of the patient, modified by the season of the year, or the prevailing type of febrile disease."[1]

The differences were merely those of degree, and were due to the comparatively good condition of the general systems of these patients into whose structures the gangrene had been inoculated.

In fact, Guthrie himself admits that —

"This gangrenous disease does not always prevail in this, its most concentrated form; the destroying process assumes more of a sloughing than of a gangrenous character, whence Delpech has denominated it pulpous rather than gangrenous. It is in its nature almost equally destructive, although not quite so formidable in appearance. It may attack the whole surface of an ulcer at once or in distinct points, all however, rapidly extending towards each other until they constituted one whole. The red of the granulations becomes of a more violet color, and the change is accompanied by burning, a pain not usually felt in the part, while a layer of ash-colored matter is soon seen covering them, which adheres so firmly as not to be readily moved, or, if separated, shows that it is a substance formed upon the surface and constituting a part of the granulations themselves, which are ultimately confounded with it.

"About the end of the first week, and sometimes much later, this kind of ulcer becomes more painful; the edges or the circumference of the wound assume a browner hue, and the parts become somewhat pasty, the whitish color of the part particularly affected being opaque, gray, and soft. It may be said that the false membrane, having become very thick, has lost the little vitality it possessed, and become putrid; the discharge, which had been partially suppressed, now reappears, not as pus, but as a fetid ichor, exhaling the peculiar offensive stench of

[1] *Commentaries on the Surgery of the War in Portugal, Spain, France, and the Netherlands.* London, 1855, pp. 162, 163.

this disease. This pulpy, yellowish, putrid substance becomes thicker and extends deeply; it invades the whole substance of a muscle, under which a probe may be passed and the instrument brought out through it, with the loss, perhaps, of some striæ of blood from parts which are not yet actually destroyed. The mass is, however, adherent, although its extent diminishes by the putrefaction and wasting away of its surface."[1]

We will examine in the next place the views of different writers upon the direct contagion of hospital gangrene.

We have already presented the views of Sir Gilbert Blane and others upon its contagious nature, supported by various facts similar to those observed in the Confederate hospitals.

M. Pouteau, chief surgeon to the Hôtel de Dieu of Lyons, who gave the first distinct account of hospital gangrene, had his attention directed to the disease at a very early period of life from his having been affected by it while employed as a dresser in the hospital to which he afterwards became surgeon.

Doctor Rollo, who wrote in 1797, fourteen years after the publication of the posthumous works of M. Pouteau, expresses the opinion that this disease is due to the action of a poison which possessed, like other poisons, the property of assimilation, or of producing matter similar to itself. The following account of hospital gangrene by Dr. Rollo, as it occurred in the Royal Artillery Hospital of Woolwich, is interesting, not only historically, but also for its accuracy and completeness: —

Description of hospital gangrene by Dr. Rollo, as it prevailed amongst the Royal Horse Artillery, 1797.

"After the formation of the brigade of Royal Horse Artillery, many accidents occurred, especially in kicks in the legs of the men by the horses' feet, and, being generally on the shin, very unpleasant sores were produced. The wound was sometimes small and punctured, having arisen from the turned-out part of the horse's shoe as formerly practiced. The bone was often laid bare. We seldom had less than forty cases at that time in the hospital.

When this sore engaged our particular attention — and from the rapidity of its progress and effects very watchful examination was bestowed — it was found that a sore of any extent (some were very considerable, as three or four by five or six inches, and others small) in the promising state of healthy cicatrization was liable to have a solitary ulceration on its edge of unequal dimensions, the size varying, being smaller or larger than a pea. This distinct little ulcer was of a darkish color, its edges jagged, its bottom unequal and ragged, and discharged a thin matter having a peculiar smell. Such was the earliest state in

[1] *Commentaries*, etc., pp. 163, 164.

which it was perceived, but probably it might have been distinguishable sooner. The disappearance of the sore in the hospital deprived us of a more minute and early inquiry.

"The day after the little ulcer had been discovered, it had acquired the size of a sixpence or a shilling, extending itself every way, even on the skin as well as on the surface of the former sore. The discharge was now changed, having become thickish, of a whitish color intermixed with dark shades, and adhering strongly to the surface of the part. The peculiarity of the smell continued, and was become more offensive.

"In another day the ulcer had spread farther, and on other parts of the former sore might probably be perceived small ulcerations of the same appearance and kind as those of the first discovery, and which went on extending until they united.

"Five or six days from the appearance of the small ulcer or ulceration, when it had extended (or by its union with other ulceration) over one third of the former sore, with pain and redness in the course of the lymphatics and the glands through which they led, with enlargement of them, general indisposition became evident. This consisted in nausea, loss of appetite, heat of skin, a very small and quick pulse, extreme irritability, a whitish tongue, and thirst. When these symptoms took place the ulceration rapidly went on, extending beyond the limits of the former sore, and destroying the adjacent parts. In this state of the sore the parts were puffed and bloody, accompanied with much uneasiness, having a burning and lancinating sensation, and the action frequently terminated in apparent gangrene. Sometimes, however, the ulcerating part remained covered with the thick, adhesive matter, and gradually, without any other apparent change, assumed the healing state.

"The operation of the poison in slowness or rapidity probably depends on some constitutional circumstance, as it was not in all of equal degrees of facility. These sores, which spread rapidly and extensively to sloughing and even to gangrene, from one, two, or more small ulcerations, very likely happened in those who might be said to have a constitutional susceptibility; while on the contrary, in those where the ulcerations continued distinct and remained covered with a thick, whitish, and adhesive matter, without acquiring the sloughing and gangrenous states, their constitutions had no favorable tendency to the operation of the poison.

"The first favorable change was in the edges of the sore, with a separation of dead parts, which went on until the whole were thrown off, and then healthy granulation and cicatrization took place.

"The most singular phenomena in the progress of this sore consisted in the various actions which were not unfrequently perceived in it at the same time, and which seemed to depend on constitutional differences. We have seen the ulcerating, suppurating, and cicatrizing states

going on at the same time in one sore. It was not unusual for the ulcerating process to be checked before it had extended over the whole sore, when the former cicatrizing parts went on without interruption, and the ulcerating part, having assumed a disposition to healthy action, arrived at the cicatrizing point, and then proceeded with the others to skinning.

"The smallness of the ulcer, the appearance of its edge and base, its ulcerative tendency, the absorption of its matter, affecting the lymphatic glands and vessels and then the whole system, pointed out the operation of a *morbid poison*.

"The action of this poison seemed to be limited and confined to specific effects; the first were local, producing only general affection by a more extended operation on the sore, and which in a certain time terminated in the healthful separation of parts, granulation, and cicatrization, and a state of constitutional convalescence.

"Sores having specific actions, as the venereal, scrofulous, and variolus, resisted this poison, and in the hospital were not affected, though such patients were in the same wards.

"Some men in quarters, one with a blistered part, another with a cut on the outer ear, and another with a sore on the leg, besides several others, were affected with the poison. The men in the same wards were not generally affected with it; those with specific sores, or with sores of small extent and having little discharge, though lying within two feet of the men under the action of the poison, escaped.

"From the very serious ravages of this poison we were induced to make the most particular inquiries. Being fully persuaded it was neither the sore acted on by erysipelas nor the sore described as peculiar to hospitals, we found ourselves involved in considerable difficulties. We consulted everything that had been written by the ancients or moderns within our reach, and we found nothing resembling our sore. We saw, however, similitudes, in some of its stages, to phagedæna, especially as it was described by Mr. Adams in his account of morbid poisons. But the local attack of this sore, its progress, and the consequent general indisposition and changes in the sore, remained new, and to us unnoticed and unexplained.

"Impressed strongly with the notion that a morbid poison was applied locally to a part of the sore, which, like the venereal poison, had the power of assimilation, and thus augmenting its power, as also of being absorbed, producing general effects on the system and a reaction on the sore, we were determined to adopt local means of treatment, consisting in the chemical destruction of the poison in parts under its direct action, and in exciting a new action.

"We were led to propose an early and vigorous treatment of the local operation from observing that when the constitutional effect took place any plan of cure was inadequate, the disease then going on and appar-

ently ceasing of itself, but not until very extensive destruction of parts had been accomplished.

"The oxygenated muriatic acid and the nitrates of silver and mercury were the applications employed, and latterly the oxygenated muriatic acid gas.

"When either of these were applied four or five times the little ulcer soon put on the suppurating state and granulated. They did not give pain in any degree, and it was of short continuance. While the ulcer was directly touched with the nitrated silver, the whole sore was moistened with a diluted solution of nitrated mercury, or a mixture of the oxygenated muriatic acid in distilled water, after which the whole was covered with lint that had been previously moistened by ether, or the oxygenated muriatic gas applied to the ulcer, and over the sore the diluted solution of nitrated mercury in distilled water.

"By these means gently persevered in, the poison and ulcer were destroyed, and the sore went on cicatrizing. The only failures were in those cases where the ulceration had so extended that the nitrated silver, or oxygenated muriatic acid gas, could not be completely employed. It is necessary to mention that washing the sore with warm water was always previously performed.

"The success of this treatment afforded additional strength to the opinion we have formed of the existence of a poison, its locality, and that it possessed, like other poisons, the property of assimilation, or producing matter similar to itself.

"Having gained this much, we were prepared to make some inquiry into its origin.

"From the local commencement of the poison, and the power we had of destroying its peculiar nature and consequent action by a direct application, and at the same time considering the circumstances of the sore previous to its appearance, we entertain the notion that the poison was formed on the surface or edges of the sore.

"In all those sores on which the poison showed itself, both in and out of the hospital, the discharge from them was considerable; they were most generally dressed with an ointment of wax and oil, spread over coarse linen, and when dressed, the matter was seldom cleaned off, by which it formed incrustations about the edge, or at a little distance from the sore. This arose from the opinion of some, that the washing of sores, if it did no harm, was at least superfluous, and from the great number of sores at that time to be daily dressed, by which less attention was probably given than might have been otherwise required and bestowed.

"We suspected, however, in a few cases, that the poison was propagated from one sore to another by means of the sponge employed in the occasional wiping or washing, the same sponge having been unguardedly used for different sores.

"The discharge of a sore, remaining confined, or some of it suffered to adhere long on the edge of the sore, may undergo such changes as to produce a matter possessing new properties of an apparently poisonous nature and effect. On several sores, but one in particular, where a considerable quantity of finely powdered nitrated mercury had been sprinkled, in twelve hours, the time of the next dressing, the mercury formed a shining crust, was firm, and appeared as if a portion of the mercury had been revived. This might be owing to hepatic gas on the surface of the sore."

The preceding observations possess peculiar interest also in the light which they throw upon the discovery and early application of the effects of the mineral acids in the treatment of hospital gangrene.

Mr. Blackadder, whose observations were made at Passages, in Spain, considers the gangrenous ulcer as specific, produced and propagated by the direct contact of specifically contagious matter to an open surface. This author considers the communication of the disease through the medium of the atmosphere as very rare, and only possible when the effluvia are allowed to accumulate in a most negligent manner, so as to resemble a vapor bath, which mode he regards as equivalent to inoculation: —

Views of Mr. Blackadder on the contagious nature of hospital gangrene.

"Whatever may be the source of the disease (says Mr. Blackadder), it is at least sufficiently ascertained, that, when it occurs, its propagation is only to be prevented by the most rigid attention to cleanliness, and by insulating the person or persons affected, so as to prevent all direct intercourse between them and the other patients; for, so far as I have had an opportunity of observing, ninety-nine cases in the hundred were evidently produced by a direct application of the morbific matter to the wounds, dressings, etc.; while others who were, in every other respect, equally exposed to its operation, never caught the disease.

"In attempting to prove this by experiment, I have placed three patients with clean wounds alternately between three other patients, severally afflicted with the disease. They lay in a part of the ward which was appropriated for patients who were laboring under the disease, and of whom there were at the time a considerable number. Their beds were on the floor, and not more than two feet distant from each other; but all direct intercourse was forbidden, and they were made fully aware of the consequences that would follow from inattention to their instructions. The result of this trial was, that not one of the clean wounds assumed the morbid action peculiar to the disease, nor was the curative process in any degree impeded."

According to Mr. Blackadder, —

"When the morbific matter has been applied to some part of the surface of the body from which the cuticle has been removed, as by a blister, one or more small vesicles first appear, which are filled with a watery fluid or bloody serum of a livid or reddish-brown color. The situation of the vesicle is generally at the edge of the sore. Its size is not unfrequently that of a split garden pea, and is easily ruptured, the pellicle which covers it being very thin. When the vesicle is filled with a watery fluid, and has not been ruptured, it assumes the appearance of a grayish-white or ash-colored slough; but, when it contains a dark colored fluid, or has been ruptured, it puts on the appearance of a thin coagulum of blood, of a dirty, brownish-black color. During the formation of the vesicle, there is generally a change in the sensation of the sore, accompanied with a painful feel, like that of the sting of a gnat.

"After a slough is formed, it spreads with more or less rapidity, until it occupies the whole surface of the original sore; and, when left to itself (which seldom happens), there is little or no discharge, but the slough acquires daily greater thickness.

"When the formation of the slough has been interrupted, the stinging sensation becomes more frequent, and active phagedænic ulceration quickly commences; and such is frequently the rapidity of its progress, that even in the course of a few hours a very considerable excavation will be formed, while the parts in the vicinity retain their usual healthy appearance. The cavity, the edges of which are well defined, is filled with a thick glutinous matter, which adheres strongly to the subjacent parts. When this matter is removed, the surface underneath presents itself of a fine granular texture, which, in almost all instances, is possessed of extreme sensibility, and is very apt to bleed when the operation of cleaning is not performed with great delicacy. At each dressing the circumference of the cavity is found enlarged, and if there are more than one, they generally run into each other. The progress of the disease is much quicker in some individuals than others, but it never ceases until the whole surface of the original sore is occupied. The stinging pain gradually becomes of a darting or lancinating pain; and either about the fourth or sixth day from the time when the morbific matter has access to the sore, or afterward, at the period of what may be termed secondary inflammation, the lymphatic vessels and glands are apt to become affected. The discharge becomes more copious, its color varying from a dirty yellowish white to a mixture of yellow, black, and brown, depending upon the quantity of blood mixed with it.

"The soft parts in the immediate vicinity of the sore daily become more painful, tumefied, and indurated; and in a great number of cases, particularly in those of plethoric and irritable habits, an attack of acute inflammation speedily ensues, and is accompanied by a great increase of pain, the sensation being described to be such as if the sore were

burning. The period at which this inflammation begins to subside is by no means regular. Sometimes it subsides in the course of two days, and sometimes it continues upwards of five; depending very much on the constitution of the patient, as well as the treatment that has been adopted. During its progress the thick, putrid-looking, and frequently spongy slough which is formed on the sore becomes more and more moist, and of a pulpy consistence. (Hence this form of disease is actually named by the Germans, pulpy gangrene.) In the course of a very few days, a very offensive matter begins to be discharged at its edges. The slough then begins to separate; by and by it is thrown off, but only to prepare the way for an extension of the disease by a continued process of ulceration, and by a recurrence of the last-mentioned symptoms."

Mr. Blackadder has still further strengthened his testimony and enriched his description of hospital gangrene by the following account of the disease from inoculation in his own person: —

"While engaged in examining the stump of a patient who had died from this disease, I accidentally wounded one of my fingers with the point of a double-edged scalpel, but so slightly that not a drop of blood made its appearance, and on this account I did not consider any particular precautionary means necessary. In the course of about sixty hours, however, the wound had become inflamed, and I was attracted to it by an occasional smart, stinging sensation, which ultimately extended a considerable way up the arm. On the fourth day the inflammation had increased, and the stinging sensation was almost constant. Headache, nausea, and general indisposition followed, with frequent chills, which increased very much towards evening; but which, with the other symptoms, were considerably relieved by the use of neutral salts, the pediluvium, and warm diluents. A vesicle, having a depression in its centre, and containing a watery fluid of a livid color, was now forming upon a hard and elevated base; the surrounding integuments became tumefied, of an anserine appearance, and extremely sensitive to the touch; at about the distance of the fourth of an inch from the base of the tumor, a very distinct areola, of a bluish-red color, made its appearance, and remained visible for several days. At this period, circumstances rendered it necessary for me to be exposed to wet, to undergo considerable fatigue, and immediately afterwards to travel to a considerable distance. The inflammation, however, gradually subsided, but the stinging, accompanied by a burning sensation, still continued, and the sore had no disposition to heal; yet it did not enlarge externally, but was disposed to burrow under the integuments. This phagedænic disposition was ultimately got the better of by laying open the sore, and by repeated applications of caustic; but it was two months before a complete cicatrix had formed. The new cuticle remained for a length

of time extremely sensitive to the touch; and it was upwards of six months before it had acquired the color of the surrounding integuments."

Views of Hennen, Delpech, and Thomson on the contagious nature of hospital gangrene.

Mr. Hennen, who has given a striking picture of hospital gangrene as it occurred amongst the wounded at Bilboa in Spain, and whose careful observations were made in the same general field, and on the same class of subjects with those of Mr. Blackadder, whilst admitting the contagious nature of hospital gangrene, at the same time gives due prominence to the condition of the system and the effects of foul air. In fact, in the treatment of the disease, Dr. Hennen placed reliance chiefly upon internal remedies, and regarded external applications as merely secondary in their effects.

Delpech, whilst admitting that the disease may be communicated through the medium of the atmosphere, at the same time affirms that, in almost every instance, he traced the propagation of the disorder to the direct application of morbific matter to the sores.

Dr. John Thomson, in his "Lectures on Inflammation," thus disposes of this question: —

"The contagious nature of hospital gangrene appears to me to be sufficiently proved, —

"1. By the fact that it may be communicated by sponges, charpie, bandages, and clothing, to persons at a distance from those infected with it.

"2. By its having been observed to attack the slight wounds of surgeons or their mates, who were employed in dressing infected persons, and that even in circumstances where the medical men so employed did not live in the same apartment with the infected.

"3. By our being able often to trace its progress distinctly from a single individual through a succession of patients.

"4. By its attacking recent wounds, as well as old sores, and that in a short time after they are brought near to a patient affected with the disease.

"5. By our being able to prevent the progress of the disease, in particular situations, by removing the infected person before the contagion which his sores emit has had time to operate.

"6. By its continuing long in one particular ward of an hospital, or in one particular ship, without appearing in other wards or ships, if pains be taken to prevent intercourse between the infected and uninfected. I have seen hospital gangrene introduced into a hospital by a single individual; and when proper precautions were not taken, spread extensively among the other patients, but chiefly among those who lay nearest in the ward to the persons originally affected, or among those

who had had most frequent intercourse with him. I have also known patients attacked in succession with hospital gangrene, who had used the same bedding, or had occupied in quick succession the same small apartment."

In like manner Guthrie, in his Commentaries, strenuously advocates the contagious nature of hospital gangrene: —

Guthrie strenuously advocates the contagious nature of hospital gangrene.

"Professor Brugmans says, that in 1797, in Holland, charpie composed of linen threads cut of different lengths, which on inquiry it was found had been already used in the great hospitals in France, and had been subsequently washed and bleached, caused every ulcer to which it was applied to be affected by hospital gangrene; and the fact that this disease was readily communicated by the application of instruments, lint, or bandages which had been in contact with infected parts, was too firmly established by the experience of every one in Portugal and Spain, to be a matter of doubt. Its character as a thoroughly contagious disease, is indisputable. Its capability of being conveyed through the medium of the atmosphere to an ulcerated surface, is also admitted, although some have thought that the infection was not always applied to the sore, but affected it secondarily, through the medium of the constitution. Brugmans says that hospital gangrene prevailed in one of the low wards at Leyden in 1798, whilst the ward or garret above it was free. The surgeon made an opening in the ceiling between the two, in order to ventilate the lower or affected ward, and in thirty hours three patients who lay next the opening were attacked by the disease, which soon spread through the whole ward. Our experience in Portugal and Spain confirmed this fact, and left no doubt on the mind of any one who had frequent opportunities of seeing the disease, that one case of hospital gangrene was capable of infecting not only every ulcer in the ward, but in every ward near it, and ultimately throughout the hospital, however large. The disease, as long as it remains unaltered by destructive applications, may be considered to be infectious as well as contagious.

"This infection can penetrate the dressings so as to affect the ulcer through them, although requiring a difference of time in different parts of the body. Ulcers on the lower extremity experienced the influence of the morbid poison in general at an earlier period than those on the upper extremity; and a wound might be seen in a healthy state on the arm, whilst one on the leg had been evidently suffering from this disease for some days, if the complaint had become mild or somewhat chronic.

"If the morbid poison were in its active state, then the deterioration of the ulcers on the arm was almost if not quite contemporaneous with that on the leg."

The following are the conclusions of Mr. Guthrie with reference to the contagious nature of hospital gangrene: —

"First. Hospital gangrene never occurs in isolated cases of wounds.

"Second. It originates only in badly-ventilated hospitals, crowded with wounded men, among and around whom cleanliness has not been too well observed.

"Third. It is a morbid poison, remarkably contagious, and is infectious through the medium of the atmosphere applied to the wound or ulcer.

"Fourth. It is possibly infectious, acting constitutionally, and producing great derangement of the system at large, although it has not been satisfactorily proved that the constitutional affection is capable of giving rise to local disease, such as an ulcer; but if an ulcer should occur from accidental or constitutional causes, it is always influenced by it when in its concentrated form.

"Fifth. The application of the contagious matter gives rise to a similar local disease, resembling and capable of propagating itself, and is generally followed by constitutional symptoms.

"Sixth. In crowded hospitals the constitutional symptoms have been sometimes observed to precede and frequently to accompany the appearance of the local disease." [1]

The preceding quotations might be greatly extended, but these observations prove conclusively that hospital gangrene may be communicated to the most simple wound or ulcer, in a healthy individual, placed in the best hygienic condition, by merely putting in contact with such wound or ulcer the poisonous matter of this disorder; and that, after the inoculation of the poison, the rapidity and extent of its ravages will be in proportion to the condition of the general system, and to the extent to which the patients have been exposed to the influence of such causes as are themselves capable of producing the disease.

In order to illustrate more fully the causes of hospital gangrene, and the principles established by the preceding discussion, we will conclude this section of the work with the results of my inquiry into the origin and causes of the hospital gangrene which prevailed so extensively amongst the Federal prisoners confined in Camp Sumter, Andersonville, Georgia.

[1] *Commentaries on the Surgery of the War*, etc., by G. J. Guthrie, F. R. S., sixth edition. London, 1855, pp. 160, 161, 171.

ORIGIN AND CAUSES OF THE HOSPITAL GANGRENE WHICH AFFLICTED THE FEDERAL PRISONERS CONFINED IN CAMP SUMTER, ANDERSONVILLE, GEORGIA.

Origin of hospital gangrene at Andersonville, Georgia.

The condition and diseases of these unfortunate men have been described in the "Sanitary Memoirs of the United States Sanitary Commission, 1867," pp. 469–655; and the preceding discussion contained in this chapter was necessary to the correct comprehension of the causes which gave rise to the hospital gangrene of Andersonville.

In the depraved and depressed condition of the systems of these prisoners, in the foul atmosphere of the stockade and hospital, reeking with noxious exhalations, small injuries — as the injury inflicted by a splinter running into a hand or foot, the blistering of the arms or hands in the sun, or even the abrasions of the skin in scratching the bites of insects — were sometimes followed by extensive and alarming gangrenous ulceration.

In the spreading ulcers of the foot, the Federal prisoners almost invariably referred the origin of the gangrene to walking in the filthy mud, mixed with human excrements, upon the borders of the stream flowing through the stockade.

Case illustrating the tendency of small injuries to degenerate into hospital gangrene.

The following drawing, Plate No. XL.,[1] was made by myself, from the arm of a Federal prisoner, who had scratched and abraded the skin around the bite of some insect, most probably that of a musquito, inflicted in the stockade.

The abrasion did not heal, but gradually assumed a dark, unhealthy hue, and the irritation commenced to spread. In two weeks it had reached the size of a silver half dollar. This patient was then transferred to the Confederate States Military Prison Hospital, and in the course of six days it reached the size and presented the appearance represented in the drawing. When I examined this patient the constitutional symptoms were well marked — hot, dry skin; small, rapid, feeble pulse; leaden, sallow, unhealthy hue of complexion; dejected, distressed countenance; coated and tremulous tongue. The stench emitted from this gangrenous mass was intolerable. The elbow joint was exposed, and the gangrenous mass presented a ragged, pulpy, putrescent mass, without pus, and with ragged, everted edges, and elevated above the surrounding tissues. It was also surrounded by a livid blue and deep purple border in the skin. This deep blue and purple areola is a sure index of the spread of hospital gangrene. The

[1] Omitted.

patient was most urgent in his entreaties for the removal of this arm; and it was decided upon consultation with the attendant medical officers, that his condition could not be rendered worse by an amputation, which would substitute a smaller flesh wound for this most extensive and foul ulcer, invading the joint and exciting intense pain. Notwithstanding the probability that in the condition of the system of this patient, in this foul atmosphere, the gangrene would return again in the stump, it was nevertheless considered proper to amputate, on account of the reasons just given.

Numerous amputations had been performed in the Confederate States Military Prison Hospital, for gangrene supervening upon slight injuries, and attacking scorbutic ulcers. I endeavored to collect all the cases of amputation for hospital gangrene, and to determine the ratio of mortality; but it was impossible to arrive at accurate results, from the almost total absence of records, and from the imperfect organization of the hospital. Hospital gangrene was not recognized among the list of diseases recorded upon the Confederate sick reports, until near the middle of 1864; and hence the disease, under the name of phagedæna gangrænosa, does not appear in the sick reports of the Federal prisoners at Andersonville prior to July, 1864. During the month of August, fifty-four cases and thirteen deaths of phagedæna gangrænosa were reported, whilst during the entire six months, two hundred and thirty cases of ulcers were recorded. I requested the medical officers on duty in the Confederate States Military Prison Hospital of Camp Sumter to prepare a classified report upon the number and character of the cases of gangrene arising from ulcerations, and following gunshot wounds and amputations, together with statements of the causes of the disease, the condition of the patient, and the nature of the treatment and the results of operations. The records of the individual wards and divisions were so incomplete that the report was imperfect.

Numerous amputations performed in the C.S.M.P. Hospital for hospital gangrene.

Upon this incomplete report, two hundred and sixty-six cases of hospital gangrene are recorded, with sixty-seven amputations in consequence of the disease, and twenty-five deaths; one hundred and two cases are given as supervening upon gunshot wounds, and the remainder were reported as gangrenous ulcers, arising from the scorbutic and deranged condition of the system. Twelve cases of gangrenous ulcers are recorded as following vaccination. These figures are far below the truth. Many cases of gangrenous ulceration which arose in the hospital were originally entered upon the hospital register under the head of scurvy, diarrhœa, dysen-

tery, or some other disease. The plan of entering the diseases as they arose in the hospital under a distinct head, as "re-admitted," was not inaugurated until the month of July, 1864; and in fact it was not properly carried into execution until the month of August. The number of deaths given above is below the true statement; for on the reports of a number of the wards, the final result was not given, and no reports were received from some of the wards. After careful inquiry, and personal examinations of the wards and patients, I was convinced that the number of amputations for hospital gangrene reached, and perhaps exceeded, one hundred.

At Andersonville hospital gangrene returned almost invariably after amputation.

Hospital gangrene returned almost invariably after amputation, in these scorbutic and enfeebled patients, and in this infected atmosphere; and in some cases the disease reappeared in the stump within thirty-six hours after the operation. The day before I arrived at Andersonville, the cars had run off the track, and been crushed against the sides of the cut through which they were passing. These railroad cars were loaded with Federal prisoners *en route* for Millen, Ga. The accident happened only three miles from Andersonville, and less than two hours after the prisoners had left the stockade. A number of the prisoners were killed and wounded. I observed the wounded who were brought to the Confederate States Military Prison Hospital daily, and noted the first appearance of the gangrene. In a case of amputation in the middle of the thigh, for a compound comminuted fracture of the foot and leg received at this time, the lips of the wound did not unite; and although the patient was a stout Irishman, and apparently in good health, in the course of twenty-four hours a deep blue line appeared along the edges of the wound, and the skin around the lips of the wound presented an excoriated, blistered appearance. The sutures came away, the edges of the wound gaped open, the flaps of the stump assumed a grayish, greenish, and bluish appearance, and in a few days the thigh bone was denuded, and projected nearly one inch from the gangrenous mass. In a second case of railroad accident, in which the cap of the knee was simply cut longitudinally, to no great depth, the wound appeared to penetrate simply through the skin; gangrene appeared in the wound in the course of fifty hours, and progressed rapidly. In another case of amputation in the upper third of the leg, for a gangrenous wound following a slight injury of the foot by a splinter, gangrene appeared in twenty-four hours after the operation, and at the end of forty hours the stump presented a blue, mottled appearance up to the knee joint.

Observations upon the rapidity with which fresh wounds become gangrenous at Andersonville.

In these cases, which became rapidly gangrenous after amputation, no pus was formed, and coagulable lymph was thrown out to a very limited extent, and the discharges assumed a thin, sanious character.

No pus formed in the wounds which became rapidly gangrenous

In the gangrenous stumps examined after death, the disorganization of the osseous and muscular structures was widespread. Stumps from which the gangrene had apparently disappeared, and which were thought to be doing well and healing, were discovered after death to be thoroughly rotten within, notwithstanding that there was but little discoloration of the skin, and comparatively little swelling. In the deranged state of the blood, and in the depressed state of the forces, gangrene appeared to affect the tissues with great rapidity, and with but slight external marks of inflammatory action. The powers appeared to be too feeble, and the blood and structures too much deteriorated, to oppose any effectual barriers to the onward march of the decay.

Wide-spread disorganization of the osseous and muscular structures in the stumps examined after death.

Without doubt, these foul ulcers and this devastating and poisonous gangrene were to a great extent but the manifestations of scurvy, if we may apply the term to a state of the system induced by sameness of diet and salt meat. It was clearly demonstrated in my report contained in the "Sanitary Memoirs," published by the United States Sanitary Commission, that diarrhœa, dysentery, scurvy, and hospital gangrene were the diseases which caused the extraordinary mortality of Andersonville. And it was still farther shown that this mortality was referable in no appreciable degree to either the character of the soil or waters, or the conditions of climate. The effects of salt meat and farinaceous food, without fresh vegetables, were manifest in the great prevalence of scurvy. The scorbutic condition thus induced, modified the course of every disease, poisoned every wound, however slight, and lay at the foundation of those obstinate and exhausting diarrhœas and dysenteries which swept off thousands of these unfortunate men. By a long and painful investigation of the diseases of these prisoners, supported by numerous post-mortem examinations, I demonstrated conclusively that scurvy induced nine tenths of the deaths. Not only were the deaths registered as due to unknown causes — to apoplexy, to anasarca, and to debility — directly traceable to scurvy and its effects, and not only was the mortality in small-pox and pneumonia and typhoid fever, and in all acute diseases, more than doubled by the

These foul ulcers and devastating poisonous gangrene to a great extent but the manifestations of scurvy.

The scorbutic condition induced by the diet at Andersonville modified the course of every disease.

scorbutic taint, but even those all but universal and deadly bowel affections arose from the same causes, and derived their fatal characters from the same causes which produced scurvy. Scurvy and hospital gangrene frequently existed in the same individual. In such cases vegetable diet, with vegetable acids, would remove the scorbutic condition without curing the hospital gangrene.

The observations of Blane, Trotter, and others, have established the fact that the scorbutic condition of the system is most favorable to the origin and spread of foul ulcers and hospital gangrene.

It has been well established by the observations of Blane, Trotter, and others, that the scorbutic condition of the system, especially in crowded camps, ships, hospitals, and beleaguered cities, is most favorable to the origin and spread of foul ulcers and hospital gangrene. In many cases occurring amongst the Federal prisoners at Andersonville, it was difficult to decide at first whether the ulcer was a simple result of the scorbutic state, or of the action of the poison of hospital gangrene; for there was great similarity in the appearance of scorbutic ulcers and genuine hospital gangrene. So commonly have these two diseases been combined, that the description of scorbutic ulcers by many authorities, evidently includes also many of the prominent characteristics of hospital gangrene, as will be seen by a reference to the descriptions of Lind, Trotter, Blane, and others.

The British seamen in Lord Anson's voyage, and in fact in all long voyages before the mode of preventing scurvy was practiced, suffered terribly from scorbutic ulcers.

John Huxham, in his "Essay on Fevers," in the chapter in which he discourses on the "dissolved and putrid state of the blood," observes that —

Observations of John Huxham on the effects of salt and half rotten provisions.

"The salt and half rotten provisions of sailors, in long voyages, cause such a sharpness and corruption of the humors, that they are rendered almost unfit for the common uses of life, producing great weakness, languors, wandering pains and aches, stinking breath, corroded, spongy gums, black, blue, and sallow spots, sordid, dark, livid, fungous ulcers, gangrenes, etc., and such scorbutics frequently fall into petechial fevers, bloody dysenteries, hemorrhages, etc. What is mentioned by the Rev. Mr. Walter, in Lord Anson's voyage, is very surprising, namely, that the blood bursts forth from the wounds of some of the scorbutics, after they had been *cicatrified* for twenty or thirty years. I have known many a ship's company set out on a cruise in high health, and yet in two or three months return vastly sickly, and eaten out with the scurvy, a third part of them being half rotten, and utterly unfit for service. About four or five weeks after they have been out, they begin to drop down one after another, and at length by dozens, till at last scarce half the complement

can stand to their duty. Particularly I remember some years since, from a squadron under Admiral Martin, we had near twelve hundred men put on shore sick at one time, though they went out very healthy, and returned in about twelve or thirteen weeks." [1]

Observations of Sir Gilbert Blane on ulcers as a result of scurvy.

Sir Gilbert Blane, in his "Observations on the Diseases of Seamen," affirms that there is no complaint more hurtful to the public service by sea and land, none more afflicting to the individual, than ulcers, and that it had been found from direful experience, in numerous expeditions, that not only those who are affected with actual symptoms of scurvy, but those who are exposed to the causes of it, and whose constitution is in such a train as to fall into it, are peculiarly susceptible of ulcers of the most malignant kind, from the smallest injury which breaks the skin.

Spontaneous origin of malignant gangrenous ulcers in the British navy. Dr. Trotter's observations.

Dr. Thomas Trotter, in his "Medicina Nautica," has in like manner recorded a large number of instances where malignant gangrenous ulcers have arisen spontaneously in various ships, and attacked with violence not only external injuries, but, in a number of cases, where neither wound, puncture, scab, or contusion could be said to have first taken place, a small circumscribed red spot would be first perceived, scarcely to be felt, but in a few hours rising to a pimple, becoming black in the centre, and inflamed round the edges, till it increased in size, swelled, and assumed every characteristic symptom of the malignant ulcer, with concomitant fever and subsequent ulceration, sloughs, and fetid discharges. This malignant or gangrenous ulcer attacked also the flesh wounds made by the lancets in bleeding for different inflammatory diseases, as catarrhs and sore throats. Contused spots, even where the cuticle was not broken, were not exempted from this general tendency to gangrenous ulceration.

On board the *Téméraire*, in 1799, every wound, abrasion of the cuticle, blistered part, scald, or burn, passed rapidly through the various stages of inflammation, gangrene, and sphacelus, in a few days, leaving the bones almost bare from the separation of immense sloughs. The tendency of the bones to caries was most marked, and many cases sank under the long confinement necessary to the separation of the dead bone.

Dr. Lind's description of scorbutic ulcers.

Dr. Lind, in his valuable work on the scurvy, has recorded the fact that the slightest bruises and wounds of scorbutic persons may degenerate into offensive, bloody, and

[1] Page 47.

fungous ulcers, which are prone to spread with great rapidity, and which are cured with the greatest difficulty.

The distinguishing characteristics of scorbutic ulcers, as given by Dr. Lind, are as follows: —

"They do not afford a good digestion, but a thin, fetid matter mixed with blood, which at length has the true appearance of coagulated blood lying cracked on the surface of the ulcer, and is with great difficulty wiped off or separated from the parts below. The flesh underneath these sloughs feels to the probe soft and spongy. No irritating applications are here of any service, for though such sloughs be with great pains taken away, they are found again at next dressing, when the same bloody appearance presents itself. Their edges are generally of a livid color and puffed up, with excrescences of luxuriant flesh arising under the skin. When too tight a compression is made, in order to keep these excrescences from arising, they are apt to have a gangrenous disposition, and the member never fails to become swollen, painful, and for the most part spotted. As the disease increases, they come at length to shoot out a soft, bloody fungus, which the sailors express by the name of bullock's liver; and indeed it has a near resemblance, in consistence and color, to that substance when boiled. It often rises, in a night's time, to a monstrous size; and although destroyed by caustics, or the knife (in which last case a plentiful bleeding generally ensues), is found at next dressing as large as ever. They continue, however, in this condition a considerable time without tainting the bone."

We might add many other facts, from various authors, establishing the spontaneous origin of malignant, spreading, gangrenous ulcers, in many navies and armies, as the result of scurvy and crowding; but the facts just recorded are sufficient to show that the foul scorbutic ulcers and hospital gangrene of Andersonville were by no means new in the history of medicine, and that the causes which induced these distressing affections have been active in all wars and sieges, and amongst all armies and navies.

The spontaneous origin of malignant, spreading, gangrenous ulcers, at Andersonville, not new in the history of medicine, but the causes which induced these distressing affections have been active in all wars and sieges, and amongst all armies and navies.

The tendency to gangrenous ulceration, as well as to the scurvy, in all its manifestations, could have been eradicated from these prisoners only by such a supply of fresh vegetables and lemons (citric acid) as it appears could not have been obtained even for the struggling armies of the beleaguered and desolated Confederacy.

Various inquiries were addressed to the medical officers, relating to the most important diseases, and especially to hospital gangrene, prevailing amongst the Federal prisoners.

Inquiries addressed to Confederate

The following report on hospital gangrene was drawn up by Dr. Thornburgh, in response to these inquiries, and forwarded to me after the completion of my investigations at Andersonville: — Medical officers stationed at Andersonville.

CONFEDERATE STATES MILITARY PRISON HOSPITAL,
CAMP SUMTER, ANDERSONVILLE, GA.,
October, 1864.

SURGEON JOSEPH JONES: —

SIR, — It was our original intention to give you in this report a description of the stockade, its location, and general condition; but learning that this would be unnecessary, we will, after stating the most prevalent diseases amongst the prisoners, confine our remarks principally to the subject of ulcers and gangrene. . . . . Report of Assistant-Surgeon Thornburgh on the diseases of Andersonville, and especially upon the hospital gangrene which afflicted the prisoners.

The diseases most commonly met with are diarrhœa, dysentery, intermittent and remittent fevers, with continued or camp fever, as many term it. We also have catarrhal affections, with occasional pneumonia and pleuritis, and above all scorbutus.

As it so rarely happens, in the course of a long experience of the medical practitioner or surgeon, that an opportunity is afforded of witnessing this most formidable and loathsome disease in all its aggravated forms, it might not be amiss to introduce in this place a detailed account of the scurvy, as it has and is still prevailing in this prison. But as that would be a work of supererogation, and lead us too far from our subject, we will not attempt the task. Out of over thirty thousand prisoners who have been confined at this place during the past spring and summer, perhaps not less than one half have suffered from this disease, in some of its various forms. As a sequel to this and the other diseases named above, we have œdema, anasarca, ascites, hydrothorax, anæmia, and ulcers of nearly every variety and form.

These ulcers are produced from the slightest causes. The scratch of a pin, the prick of a splinter, a pustule, an abrasion of the skin, or even a mosquito bite, are sufficient causes for their production.

The phagedænic ulcer is the most common variety met with amongst the prisoners, and usually commences from some of the causes just enumerated, or from wounds or injuries of a more serious nature. When from any of these causes an ulcer forms, it speedily assumes a phagedænic appearance, and extends over a large surface, and presents irritable, ragged, and everted edges, and slowly destroys the deep tissues down to the bone. The surface presents a large ash-colored or greenish-yellow slough, and emits a very offensive odor. After the slough is removed by appropriate treatment, the parts beneath show but little tendency to granulate; occasionally, however, apparently healthy granulations spring up around and within, and progress finely for a time, and again fall into sloughing, and thus by an alternate process of sloughing and phagedænic ulceration, large portions of the

affected member, or large masses of the body, are destroyed. In this condition the gangrene frequently progresses with great rapidity, and if not speedily arrested, soon puts an end to the poor sufferer's existence.

Gangrene first made its appearance in the stockade in the latter part of April, or first of May last. The first that came under our observation was the result of frost-bite. These cases (three or four in number) occurred among the prisoners who had been imprisoned on Bellisle, Richmond, Virginia, last winter, where they received the injury. The parts attacked from this cause were usually the toes. The treatment was cold-water dressing, and the whole affected member enveloped in cloths spread with simple cerate ; tonics were also administered to support the system. This treatment usually succeeded, with the loss perhaps of one or more of the affected toes.

Early in the spring small-pox made its appearance in the prison, and as a prophylactic measure, we were ordered to vaccinate all who could not show the proper vaccine scar ; consequently we went to work, and in a week or ten days two or three thousand were vaccinated. Out of this number, nearly every prisoner who happened to be affected with scurvy was attacked with ulceration of the pustule. These small ulcers soon began to slough, and extend over a large extent of surface ; when the superficial sloughs were separated, the parts beneath were found to be in an unhealthy sloughing condition ; finally these ulcers would become phagedænic, and destroy every structure in their tract for a considerable extent. In this condition gangrene would set in, and if the disease was not speedily arrested by powerful escharotics, emollient poultices, and the proper vegetable diet, amputation became necessary, or the poor sufferer sank under the irritation. Diarrhœa and dysentery frequently supervened, and speedily destroyed the patient.

The next and most common form of ulcer with us is what we call the scorbutic ulcer. In cases of scurvy, we have the upper and lower extremities covered with blue or livid spots, varying from the size of a millet seed to three or four inches in diameter, or the whole limb may become of a dark livid or copper color ; the blotches become painful, open, and ulcerate ; this condition continues for a time, when the sloughing is so extensive as to destroy whole toes, feet, and even arms and legs, the affected parts apparently not having sufficient energy or vitality to set up inflammatory action. The most prominent symptoms of this kind of gangrene are a weak and small pulse ; great prostration of the already enfeebled vital powers ; a dry, glazed tongue ; great anxiety of countenance ; with a foul, grayish slough all over the surface of the wound or ulcer, which discharges a large quantity of filthy and very offensive sanies, destroying everything before it, to the bone. If an operation be not in such cases resorted to, we have hemorrhage, caused by the destruction of the blood-vessels of the part. We have operated on perhaps twenty or thirty cases in this condition, and we do not

recollect a single case where the gangrene did not reappear in the stump and speedily destroy the patient.

In the other forms of gangrene, however, we have had much better success. Out of perhaps one hundred operations, twenty or thirty are well, and as many others doing well, apparently. We think this a fair estimate of all the capital operations performed in this hospital during the spring and summer.

The treatment adopted in all forms of gangrene consists of such tonics as quinine, tincture of iron, tinctures of salix, eupatorium perfoliatum, and such other indigenous remedies as we can obtain from the woods. We are now making some experiments with a decoction of the baptisma tinctoria, which grows abundantly around the hospital. As local applications, we use nitric acid, nitrate of silver, tincture of iodine, oil of turpentine, and Darby's prophylactic fluid, followed by emollient poultices made of powdered flaxseed, or a common mush poultice, made by thickening a strong decoction of red-oak bark with corn meal.

The following is a tabular statement of the patients received and treated in one ward, namely, No. 5, second division, Confederate States Military Prison Hospital, Andersonville, during the past three months. We regret not being able to give you a similar report for the entire hospital.

NUMBER OF PATIENTS TREATED IN WARD NO. 5, SECOND DIVISION, C. S. M. P. HOSPITAL, ANDERSONVILLE, DURING THE MONTHS OF JULY, AUGUST, AND SEPTEMBER, TOGETHER WITH FIVE DAYS OF OCTOBER, AND RESULTS OF TREATMENT AS FAR AS KNOWN.

Present in Ward.				Admitted.				Sent to Quarters.				Detailed.				Transferred.				Died.				Remaining in Ward.			
July 1.	August 1.	September 1.	October 6.	July.	August.	September.	October 6.	July.	August.	September.	October 6.	July.	August.	September.	October 6.	July.	August.	September.	October 6.	July.	August.	September.	October 6.	July 31.	August 31.	September 30.	October 6.
68	77	72	62	80	106	57	12	0	4	0	7	1	4	6	2	10	15	14	8	66	86	47	7	66	79	62	50

It will be seen by the above statement that we treated, in a little more than three months, 325 patients; and out of that number 208 have died; 47 were transferred to other wards; 13 were detailed for duty in hospital as nurses (after they were cured); and 11 were sent to quarters cured, which leaves 50 still in the ward, October 6; and out of the 50, there are two or three about well, four or five convalescent, and the remainder pretty badly off.

In the month of August, we had in the 5th ward twenty-one operations of all kinds; out of these cases we had ten deaths, attributable chiefly to diarrhœa and dysentery, while only two or three were caused by recurrence of gangrene in the stump.

In September, we had eleven operations for the same condition, of which seven died from diarrhœa and dysentery.

The whole number of operations for the two months (August and September) were thirty-eight, of which seventeen died, nine were transferred to other wards, six are convalescent in the ward, and we know of four or five others who were transferred to other wards, and who are also convalescent. The deaths, as far as known, are reported in the above.

We will now give you a case of what we took for true hospital gangrene: —

J. Mailer, aged twenty-four years. Admitted August 5, with a large sphacelus covering the whole arm, up to within two and a half inches of the shoulder joint. The arm was very much tumefied, and presented around the border of the large sphacelus a kind of erysipelatous inflammation; this inflamed surface was covered with green and yellow spots; these in turn opened, and discharged filthy and very offensive sanies. The pulse beat 120 to the minute, was weak, and had a peculiar vibratory thrill. Tongue dry and glazed; very red at the tip and the edges. Bowels a little loose, but not amounting to diarrhœa. Appetite poor. Urine scant, and high colored. Complains of considerable pain in affected arm and shoulder; has copious night sweats; complains of chilliness of mornings, and fever in the afternoon. (Sulphate of quinia, grs. xx.; Dover's powder, grs. x.; mix and divide into eight parts; one of these powders to be given every six hours, in one fluid ounce of good whiskey. Apply pure nitric acid to the gangrenous parts, and envelop the whole arm in a flaxseed poultice.)

August 6. — Patient no better; is very anxious to have the arm amputated. Gangrene extending. Pulse 125 in the morning, and 137 in the evening. Tongue about the same. Bowels still loose. Appetite somewhat improved. Fore-arm œdematous. (Continue treatment.)

August 7. — Gangrene still extending above the elbow. Presents a pea-green appearance, and emits an intolerable odor. Pulse 130, at 8 o'clock A. M.; 141, at 5 o'clock P. M. Bowels painful. Has mucous discharges. Appetite weak. Cannot obtain diet of proper kind.

August 8. — This morning the gangrene has extended into the shoulder joint, and half-way to the hand. Pulse 140 in the morning, and 157 in the evening. Patient has dysentery. (Continue treatment, and administer internally turpentine emulsion.)

In this condition the patient remained up to the 10th instant, at which time he began to sink, and died on the 14th instant, with the whole arm in a state of sphacelus.

Now if this be hospital gangrene, we have had quite a number of cases. . . . .

We will now endeavor to answer the questions upon hospital gan-

grene with which you honored us, whilst prosecuting your investigations amongst the sick and wounded of the Confederate States Military Prison Hospital.

We take the ground that we have hospital gangrene in its most aggravated form in this hospital; and also that it has prevailed, and is still prevailing to an alarming extent amongst these unfortunate prisoners. We regard the sloughing phagedæna, so common and so fatal in its consequences, as a true type of this disease. We have had under our immediate care a goodly number of cases of this disease within the last few months, and have witnessed a great many more in other wards, and have consulted with various medical gentlemen on the subject, and find but few who differ in opinion with reference to the disease usually diagnosed phagedæna gangrænosa being hospital gangrene.

From the experience we have had with hospital gangrene, we regard it as a constitutional disease, from the fact that it is invariably attended with constitutional symptoms, generally of a low grade. These symptoms may or may not precede the local invasion of the disease. If the constitution of the patient is greatly deteriorated by previous disease, as from scorbutus or chronic diarrhœa, we usually have primary symptoms, such as great depression of the vital powers, anxious countenance, quick and feeble pulse, and a dry, red, or glazed tongue. Fever and other constitutional disturbances are invariably met with in this disease, but do not always precede it. When the disease is brought on in healthy patients, with fresh wounds, by contagion, we have the above symptoms following the local disturbance or invasion of the disease.

We have had no chance of settling the question of contagion in this hospital. Our patients have been crowded together on the same ground with other patients, suffering from the various diseases incident to the prisoners, and in very many instances in the same tent, or even in the same bed. Again we have only one wash-pan to the tent, and it is utterly impossible for the nurses, if they were ever so particular, to keep those who have no gangrene from using the same basin as the gangrene patients. The same sponge is doubtless often used for every patient in the tent; and owing to the great scarcity of bandages, we are compelled to use the same several times, and in washing they are not unfrequently changed, and applied to healthy wounds, and thus the disease may be transmitted from one patient to another by actual contact. So we are not in possession of the proper data to justify us in giving an affirmative answer as to the disease being contagious; but from our limited experience with the disease, and from what we know of its nature and general character, we are inclined to the opinion that it is highly contagious.

We have not the least doubt of the constitutional nature of the disease, but cannot speak from experience of the success of a strictly con-

stitutional treatment. We are always so anxious to relieve our patients of whatever disease they may chance to have, that we make every effort for their relief in our power; hence we have never treated this disease without using local applications, nor do we believe that we would be justified in making the experiment of treating hospital gangrene by constitutional means only. With the life of a human being in our hands we would not think of risking constitutional treatment alone, therefore we cannot answer the question from experimental knowledge.

Hospital gangrene may appear in slight wounds, even in perfectly healthy patients, if they should be exposed to the atmosphere in which patients are confined who are suffering from this disease.

Having never tried the experiment of inoculation with gangrenous matter, we cannot speak positively, but we have no doubt that we should have a modified form of the disease as a result.

We do not believe that this disease ever originates spontaneously in well regulated and properly ventilated hospitals, unless the patients are overcrowded and neglected. Still, such cases are on record; but it will be remembered that at the time of their occurrence other diseases were prevailing epidemically, such as influenza, erysipelas, and phlebitis, which may, under certain circumstances, act as one of the causes of this affection. Influenza prevailed very extensively in the prison about the time this disease originated, and may have had something to do with its production. Let the causes be what they may, when the disease is once established in an extensive hospital, it generally spreads rapidly by contagion, or otherwise, and its rapid spread is only checked by isolating all who are affected with the disease from the other sick and wounded.

The essential conditions and causes of the disease under consideration are of various kinds, such as derangement of the blood, overcrowding in hospitals, a lack of proper cleanliness, and insufficient ventilation. In fact, everything which causes diseases of a low form might be enumerated as causes of this truly formidable disease. . . .

Very respectfully,

Your obedient servant,

A. THORNBURGH,

Assistant-Surgeon P. A. C. S.

The exhalations from the prison and hospital extended beyond these localities and affected the Confederate soldiers guarding the prisoners, and induced hospital gangrene.

The exhalations from the gangrenous wounds of the Federal prisoners in the hospital and stockade appeared to extend their effects to a considerable distance outside of these localities. Thus the Confederate soldiers guarding the prisoners, who did not enter the stockade or hospital, but who only stood guard in the sentry-boxes along the top of the stockade, were in several instances attacked with hospital gangrene, as will be seen in the following case: —

CASE LIV.—General Hospital for Confederate soldiers, Andersonville, Ga., September 22, 1864. Thomas Cole, private, 3d Regiment Georgia Reserves, Company H. Age, sixteen; height, five feet nine inches; weight in health, one hundred and fifty pounds. Arrived at Andersonville on the 20th of July. Was engaged in guarding prisoners at the stockade. Performed guard duty every third day; two hours on and four hours off, during the twenty-four hours. Before leaving home received a slight scratch on the side of the left foot, a little below the ankle. This boy did not usually wear shoes at home, and on the way to Andersonville the shoes bruised and enlarged the small injury. This small abrasion did not heal after the commencement of his duties as a soldier at Andersonville.

Case LIV. Illustrating the origin of hospital gangrene amongst the Confederate soldiers guarding the Federal prisoners at Andersonville.

It did not, however, give him any special trouble, or appear inflamed, until about the first of September, three weeks ago, and forty-two days after his arrival at this post. Up to this time this young recruit had never been inside the stockade, and had never stood guard around or within the hospital. On the 4th of September, the patient was compelled to quit duty, and on the 12th instant (ten days ago), he was transferred to the Confederate General Hospital.

At the time of his entrance into the hospital the gangrenous spot was not larger than a silver half dollar, and presented an inflamed areola in the sound skin, elevated, everted edges, and elevated, pulpy, ragged, greenish and grayish central mass.

Up to the present time, the gangrene has spread rapidly, and the wound now presents the appearance represented in the following figure, which I rapidly sketched from life. (Plate No. XLI.[1])

Hemorrhage was constantly taking place from numerous small eroded vessels, and hence the red and mottled appearance of certain portions of the gangrenous mass. Several smaller gangrenous spots were visible upon the leg, and are represented in the figure. These are said to have arisen spontaneously; that is, without any preceding abrasion or injury. The black mass in the centre of the large ulcer upon the ankle joint appeared to be the surface of the necrosed bone.

The constitutional symptoms were well marked in this case. At night when I examined the patient, he had hot fever, with rapid pulse, pale, anæmic, sallow, unhealthy complexion. This morning, has less heat of surface, and the pulse is less frequent, but still there is febrile excitement, and he is very nervous and weak; cries like a child when his wound is touched, even in the gentlest manner. Bowels loose; had a large, loose, yellow, very offensive evacuation whilst I was engaged in executing the sketch.

In this Confederate hospital at Andersonville, I observed a patient with the thigh amputated at the lower third; the history of this case was similar to that just given.

Another case illustrating the origin of

[1] Omitted.

hospital gangrene amongst the Confederate soldiers guarding the Federal prisoners at Andersonville.

This Confederate soldier had suffered for several years with a small indolent ulcer of the foot. After coming to Andersonville, and performing guard duty for several weeks, this ulcer became gangrenous, and the parts were so rapidly and extensively disorganized, and the bones denuded of muscles, that amputation was deemed necessary. At the time that I examined this patient, he was isolated in a tent.

After the amputation, gangrene reappeared in the stump, but the use of nitric acid, and the constitutional treatment with quinine and tincture of the sesquichloride of iron, arrested the progress of the disease, and the stump is now suppurating. The pus, however, is unhealthy, thin, and offensive, and the constitutional symptoms are unfavorable —weak, feeble, rapid pulse, hectic flush on cheek, sallow, unhealthy, leaden hue of complexion, bowels loose, no appetite, depressed spirits.

Post-mortem examinations conducted by author at Andersonville.

I instituted a series of post-mortem examinations designed to illustrate and determine the true causes of the great mortality amongst the Federal prisoners confined at Andersonville. The following observations are selected as illustrations of the subject now under consideration :—

Case LV. —Julius Bozwood, sergeant, Company I, 15th New York Cavalry. Jew by birth and religion; hatter by occupation before entering the United States service. Was captured on the 14th of May, near Newmarket, Virginia, 1864. Arrived at Andersonville on the 15th of June, 1864. During his confinement in the stockade, accidentally stuck a small splinter into the plantar surface of the left foot. This occurred shortly after his entrance into the Confederate States Military Prison. The patient states that this slight injury pained him, and commenced to ulcerate shortly after wading in the filthy mud along the banks of the stream flowing through the stockade. The patient expressed his firm belief that this mud had poisoned the wound.

Case LV. Illustrating the origin and nature of hospital gangrene at Andersonville.

Assistant-Surgeon A. Thornburgh, furnished me with the following facts and outline of this case.

The ulcer became gangrenous about the 3d of July, and continued to increase in size up to his admission into the Confederate Military Prison Hospital, on the 10th of this month. At the time of his entrance into the hospital the patient was found to have a large mass of black putrid matter immediately under the instep of the right foot. The edges of the gangrenous mass were swollen, everted, and surrounded by a circle half an inch wide, and of a livid hue. Pulse, 78; tongue slightly furred; respiration natural; urine high colored; appetite good; bowels regular, with natural discharges; no appearance of scurvy. The gangrenous parts were freely touched with nitric acid, morning and evening, and dressed with flaxseed poultices.

This treatment was continued to the 14th, when a large slough separated, leaving the parts exposed nearly to the bone. The diseased parts were then bathed freely in a strong solution of chlorate of potassa. Ten drops of the tincture of sesquichloride of iron were administered three times a day, and the wound dressed with simple cerate. Under this treatment the patient continued to improve up to the 1st of August, at which time the ulcer was covered with healthy granulations.

August 2. — The ulcer looks pale, with dark or livid spots about the centre. Margin of ulcer livid and everted. (Nitric acid to the parts, followed with flaxseed poultice. Continue tincture of the sesquichloride of iron.)

August 3. — Whole foot tumefied; edges of ulcer completely everted. The entire surface of the ulcer of an ashy hue, with a dark or muddy and very offensive discharge. Pulse 100 in the morning, and 115 in the evening. Tongue coated with thick, brown fur. Appetite failing. Yellow patches are appearing in the livid circles surrounding the ulcer.

August 4. — No improvement; condition much the same.

August 20. — No improvement, and the condition of the patient has continued with little alteration since the last observation. At the present time the pulse is 114, and very compressible and feeble. Tongue coated, with dark color and dry fur. No appetite; urine scant and high colored. Slight cough, with pain in right side near the fifth intercostal space. (Quinine, grs. xii.; Dover's powder, grs. xv.; mix, divide into five powders, and give one every six hours in whiskey.)

August 23. — Patient much the same. Continue treatment.

August 27. — Patient says that he feels much better, but has considerable œdema of the lower extremities, and slight tumefaction of abdomen. Pulse, 107. No improvement in appetite. Urine still scanty and high colored. The whole ulcer in a state of sphacelus, much larger than at any previous period. (Discontinue quinine; resume tincture sesquichloride of iron, gtts. xx., three times a day; Dover's powder, grs. x., at bed-time. Apply nitric acid to ulcer, and follow with flaxseed poultices.)

September 4. — Patient growing worse. Pulse 125, very feeble. Skin of extremities cool. For some time has been suffering with diarrhœa, which on the 2d instant increased to a most troublesome and dangerous extent. Last night the patient passed bloody mucus from the bowels. No appetite. Intellect clear. Vital forces appear to be failing fast. Pain in the bowels considerable, and the abdomen is much swollen, and is tympanitic. (Turpentine emulsion, tea-spoonful every six hours; whiskey, f℥ii., during the day.) Diet such as the prison hospital affords, and not what could be desired in such a case, consisting of boiled beef and rice, and unbolted corn meal, without milk, tea, coffee, or butter. The patient is unable to eat his rations.

September 10. — Pulse 131, A. M.; 137, P. M.; weak and thready. The bloody discharges mixed with mucus have nearly disappeared, and the discharges from the bowels present more nearly the appearance of those of diarrhœa. Continue treatment.

September 12. — Continues to grow worse. Bowels still swollen and tympanitic. Ulcer looks dry and black from passive hemorrhage last night.

September 15. — Patient says that he is dying. Pulse 141, very feeble. His complexion has presented an ashy, deathlike hue for several days. Tongue dry and hard. Has no appetite or power to eat.

September 18. — Died at six o'clock P. M.

AUTOPSY, *Eighteen Hours after Death.* — *Exterior.* — Body greatly reduced in flesh, but the emaciation was not so great as in many other cases which I examined.

Gangrenous ulcer in plantar surface (bottom) of left foot, oval in shape, between three and four inches in diameter, and extending entirely across the hollow of the foot, rose up for an inch or more along the inner side of the foot, and involved extensively the ligaments, tendons, and bones of the instep. This ulcer was of a dark greenish and purplish hue, and emitted a most horrible stench.

I dissected the femoral and popliteal veins of the diseased leg, and drew out a firm clot of coagulated blood.

The arteries were empty.

The blood-vessels leading to and from the ulcer and diseased structures, were carefully examined, but no pus was discovered.

It is a matter of interest that there should have been so marked coagulation of the blood in this case of hospital gangrene; while in those bodies in which gangrene had not appeared, the blood in all parts and in all the blood-vessels was fluid.

Reaction of gangrenous ulcer alkaline.

Head. — Dura-mater healthy. The longitudinal and lateral sinuses contained well defined and firm clots of coagulated blood, which could be drawn out, and possessed considerable tenacity.

Arachnoid and pia-mater more congested than in the cases uncomplicated with gangrene; but in the present case those membranes presented no marks of inflammation, and nothing abnormal beyond a moderate degree of congestion. The intellect had been clear up to the time of death.

The arachnoid was separated from the pia-mater by light yellow serous fluid, which also infiltrated the fibrous tissue of the pia-mater. The lateral ventricles of the brain contained each about three fourths of a fluid ounce of serous fluid. The structures of the brain appeared to be normal, being neither softened nor hardened, nor altered in color.

Chest. — Heart somewhat larger than usual, and of a brownish yellow, pale color.

The pericardium and heart showed marks of a former attack of pericarditis and endocarditis; fibrous matter (coagulable lymph) had been thrown out extensively upon the external surface of the heart, and upon the internal surface of the pericardium, and the valves of the heart were also thickened from this deposit, the result of inflammatory action. This fibrous deposit was of long standing, and the inflammatory action in which it was thrown out must have long preceded the last fatal illness, and from all appearances occurred before the entrance of this soldier into the United States service.

The right auricle and ventricle contained a large golden-colored polypus (fibrous concretion), which sent branches several inches in length into the pulmonary arteries. The fibrous clots were in great measure free of colored blood corpuscles, and were firmly attached to the columnæ carnæ and cordæ tendinæ. The left auricle and ventricle also contained golden-colored fibrous clots, attached in a similar manner.

Lungs. — Numerous adhesions of an old date. These adhesions were firm, elastic, and by no means of recent date. These organs were somewhat congested, and when cut, mucus, mixed with some pus, issued from the bronchial tubes.

Abdominal Cavity. — Liver slightly darker and more mottled than in health, upon the anterior surface; upon the inferior surface, of a slate color, like that of malarial fever. Structure of liver firm.

Spleen. — Enlarged, about twice its natural size, but not softened, and the enlargement appeared to be the result of a previous attack of malarial fever. Pancreas healthy.

Alimentary Canal. — Stomach distended with gas, and of a greenish yellow and gray color upon the exterior. Mucous membrane of stomach of a greenish-yellow color, with numerous dark purple and almost black arborescent patches of gangrene.

Small Intestines. — The mucous membrane of the intestinal canal was generally of a slate and brownish-gray color, and softened, as if in a gangrenous state. The small intestines were distended with gas, and upon the exterior presented a bluish and greenish color.

Large Intestine. — Ulcers were scattered over the mucous membrane of the colon, which presented blue, gray, ash, and greenish-yellow colors. No appearance of ordinary red blood was seen in the blood-vessels of the mucous membrane, although they were filled with this fluid in an apparently disorganized state.

The appearance of the mucous membrane of the colon in this case is represented in Plate No. L.[1]

The mucous membrane of the rectum was extensively ulcerated, and covered with a yellow fibrous deposit. The mucous membrane of the

[1] Omitted.

rectum was also in a state of gangrene, and presented a bluish and grayish color. Plate L.[1] represents the general appearance of the mucous membrane of the rectum in this case.

The walls of the abdomen presented a dark greenish hue, and the muscles presented a dark purplish and greenish color, as represented in Plate L.

The dark-colored blue muscles of the abdominal walls gave an alkaline reaction; and when the muscular fibres were examined under the microscope, numerous prismatic crystals of triple phosphate were discovered amongst the fibres.

Commentary. — This case presented all the local and constitutional symptoms of hospital gangrene. I examined the patient carefully upon several occasions, and found the pulse very frequent and feeble, and the complexion of a sickly, sallow, leaden hue; the countenance anxious and depressed; the temperature elevated above the normal standard, and subject to marked variations during the twenty-four hours.

Commentary.

The fact that the prisoners in most cases attributed the origin of gangrene in the foot to the poisonous action of the morass of human excrement on the banks of the stream in the stockade, does not at all demonstrate that this mud was capable of poisoning a wound and rendering it gangrenous, for gangrene attacked the upper extremities after injuries, just as frequently as the lower. And gangrene followed railroad accidents, gunshot wounds, and even vaccination and amputation, within a short period, and in some instances within fifty hours after the reception of the injury. In my numerous examinations of the wounded in the filthy tents and in the foul atmosphere of the hospital, I observed every variety of appearance in the stump after amputation, from fully developed gangrene to the denuded stump, with the dead bone protruding several inches; and after an inquiry into the various causes, was led to refer the extensive prevalence of the disease to the condition of the patients, induced by long confinement, sameness of diet, salt meat, scurvy and exposure, and filth and crowding, and to the extensive use of rags which had been applied to gangrenous wounds, and to the neglect of all those precautions so essential to prevent the spread of a contagious disease like hospital gangrene.

The presence of clots in the heart and veins, in this case of hospital gangrene, whilst they were entirely absent from the cases which had never suffered from gangrene, was of interest as sustaining the view that gangrene is accompanied with inflammatory

[1] Omitted.

action in the general system, as well as in the textures surrounding the local disease, in which action the fibrous element and coagulability of the blood is increased, even in those patients who had been reduced in flesh and exhausted by bad food and diarrhœa.

The change in the color of the mucous membrane of the intestinal canal appears to have been ante mortem to a great extent, and was probably due in great measure to the absorption and action of the poison of hospital gangrene.

Case LVI. Federal prisoner. Confederate States Military Prison Hospital, Andersonville, Georgia. A small injury in the hand, from a sharp bone, whilst this prisoner was performing police duty in the hospital grounds, was followed by hospital gangrene, and the fore-arm was amputated near the elbow joint. Gangrene appeared again, and the arm was amputated about three inches from the shoulder joint. Gangrene appeared again; but under local and constitutional treatment the stump appeared to improve. At the time of my examination, two days before the death of this patient, the stump appeared to be doing pretty well, as far as the absence of great swelling and discoloration of the skin extended; but it emitted a thin, stinking sanies. Notwithstanding that there was but little swelling and discoloration of the external cutaneous surface, the discharge from the stump was thin, greenish, unhealthy, and fetid. The flaps appeared to be partially united, and the bone was not exposed. The patient, however, was very weak, and greatly emaciated from an exhausting and obstinate diarrhœa, and from the effects of the amputations and gangrene.

Case LVI. Illustrating the origin and nature of hospital gangrene at Andersonville.

The absence of swelling in the stump may have been due in great measure to the reduced condition of the patient and the exhausting diarrhœa.

Autopsy, *Six Hours after Death.* — *Exterior.* — Emaciation extreme; a mere skeleton. Wound with dark brown and green edges, and emitting a fetid, bloody, and sanious fluid, with a most disagreeable gangrenous odor. When an incision was made from the wound upwards to the shoulder joint, the structures were found to be thoroughly disorganized and broken down, gangrenous, and infiltrated with dark grumous blood.

The bones of the head of the humerus, and neck of scapula, were rough, completely denuded of periosteum, and apparently dead. The surrounding muscles were disorganized, and readily crushed upon slight pressure. Notwithstanding this extensive disorganization of the internal structures, the skin showed no discolorations, except a slight greenish tinge, and several small blisters. There were no signs upon the exterior indicating the extent of the internal disorganization. In fact, I had

been informed by the attendant physician, only a day or two before the death of this patient, that the wound was doing well, and was free of gangrene.

I examined the subclavian, vena innominata, and jugular veins, but did not discover any pus in these vessels, or any marks of inflammation or disorganization in their coats. The adjacent lung also was examined with care, without discovering any evidence of the transference of the gangrene to this organ.

A small isolated abscess, filled with pus, was discovered in the walls of the abdomen, just over the region of the bladder, and above the symphysis pubis. Reaction of gangrenous matter in stump of arm alkaline.

Head. — Brain presented the same appearance as in the preceding cases. Dura mater healthy. Serous effusion, between arachnoid and pia mater. Ventricles filled with light yellow, clear, serous fluid. Structures of cerebrum, cerebellum, medulla oblongata, and spinal cord without any appearance of disease, and apparently healthy.

Thorax. — The heart contained well-formed fibrous clots, as in the preceding case. Pericardium, as in the preceding case, distended with yellow serum.

Muscular structure of heart of a pale, brownish yellow color, anæmic and flabby.

Lungs. — Healthy.

Abdominal Cavity. — *Alimentary Canal.* — Upon the exterior greatly congested, and dark-colored in different portions.

Stomach. — Mucous membrane highly rugose, with rose-colored, punctated, congested rugæ.

Small Intestines. — Mucous membrane apparently healthy in many parts, but in other portions highly congested, especially in the region of the ileo-cæcal valve.

Large Intestine. — The mucous membrane of the colon, near the ileo-cæcal valve, was of an intense red color, as represented in Plate No. LI.[1] Under the magnifying glass the villi of the intestine appeared swollen, and in some portions of the intestines they were absent, as if these structures and the epithelium had been denuded. In all the highly congested portions of the intestinal mucous membrane, the villi were intensely congested, and the mouths of the tubuli (tubular or Lieberkühnian glands — cryptæ mucosæ) appeared to be filled with blood. Through large tracts of the colon the congestion was as intense as that represented in Plate No. LI., and resembled the surface of raw flesh; and under the magnifying glass the tubular glands presented the same appearance as if their mouths were filled with blood. The rectum was greatly but not uniformly congested. Plate No. LI. represents the appearance of the rectum in the most highly congested portions.

[1] Omitted.

Liver. — This organ presented a darker color than in the preceding case, and the lower surface was of a slate color.

Spleen. — Enlarged about three times its normal size, but firm in structure, and not softened. If this change was not the result of malarial fever, it was of long standing. Gall bladder distended with bright yellow bile. The stomach contained much bilious matter mixed with mucus; and as in other cases which had been similarly affected with chronic diarrhœa, the entire alimentary tract contained bile in large quantities. Pancreas healthy. Kidneys healthy. Reaction of contents of colon and rectum alkaline.

Case LVII. Illustrating the nature of the hospital gangrene at Andersonville.

Case LVII. Federal prisoner. Confederate States Military Prison Hospital. Death caused by diarrhœa, dysentery, and supervening gangrene, September 20, 1864.

Autopsy, *Twelve Hours after Death.* — *Exterior.* — A mere skeleton. Sunken eyes, and thin, wasted limbs. Bed-sore over region of sacrum. The anus appeared to be gangrenous. When the body is laid upon the face, the anus is very much relaxed, and it is possible to look into the rectum for the distance of an inch or two. It presents the appearance of the parts in hospital gangrene; the edges are swollen and everted. The color is of a bluish green, and numerous small maggots are crawling in and out.

Head; Brain. — Blood-vessels filled with blood. This brain is somewhat more congested with blood than in the other cases of diarrhœa, but presents nothing abnormal, however, as far as the amount of blood and the consistency of the structures are concerned. Serous effusions between the membranes of the brain; œdema of the fibrous tissue of the pia mater, as in the preceding cases. Substance of brain somewhat more watery and serous than usual in those dying in comparatively vigorous states, and in comparatively healthy conditions of the blood. Ventricles of the brain filled with light yellow serum. Structure of brain normal, neither softened nor indurated.

Thorax. — Heart pale, anæmic. Right auricle and ventricle contained heart clots, partially devoid of red corpuscles. Lungs with old adhesions, but apparently healthy.

Abdominal Cavity. — Liver dark mottled color; slate and purple upon the anterior surfaces, and slate-colored upon the posterior. When cut, the liver was found to inclose numerous bubbles of gas, and it was evident that decomposition had progressed to a considerable extent. The peculiar color of the liver appeared to be due to its decomposition; and from the comparatively short period which had elapsed after death, as well as the condition of the intestinal canal, it is probable that the liver was in a state of incipient gangrene at the time of death.

Spleen. — Enlarged to three times its natural size, but not specially softened. This enlargement was evidently not recent. It is probable

that at some former time this patient had suffered with malarial fever.

Alimentary Canal. — The mucous membrane of the stomach and intestines presented a green and grayish, bluish mottled appearance, with black patches. The structures were softened, as if in a gangrenous state.

The colon and rectum throughout their entire extent were ulcerated, and the ulcerations presented evidences of gangrene, being green and bluish and black, and emitting the disagreeable odor of hospital gangrene. Plate No. LI.[1] represents the color and appearance of a large ulcer, and of the surrounding mucous membrane in the transverse colon.

Commentary. — As far as we were able to form an opinion in this case, the alterations in the color of the mucous membrane of the alimentary canal in a measure preceded death. If it be true that gangrene supervened in the diseased intestinal structures before the close of life, and probably in the seventy hours preceding death, the important fact is established, that hospital gangrene, or a disease resembling it in all essential respects, may attack the intestinal canal of patients laboring under diarrhœa and dysentery, accompanied with ulcerations of the mucous membrane, although there be no local manifestations of gangrene upon the surface of the body.

Commentary.

CASE LVIII. Hospital gangrene accompanied with chronic diarrhœa. Federal prisoner. Confederate States Military Prison Hospital, Andersonville, Georgia.

Case LVIII. Illustrating the nature of the hospital gangrene at Andersonville.

This patient had injured his foot slightly in the stockade, by striking against a small stump. The injured limb (left leg) was amputated at the lower third, in consequence of the extensive ravages of hospital gangrene in the foot. Gangrene reappeared in the stump, and ten days after the amputation the patient died.

AUTOPSY, *September* 21, 1864, *Six Hours after Death.* — *Exterior.* — Body emaciated, but not to so great an extent as in the preceding case. Stump of left leg swollen. The bones project from the ragged, gangrenous mass two inches. Large, deep, and dark-colored bed-sore upon the sacrum.

Head. — Brain presented much the same appearance as in the preceding cases. Blood-vessels moderately filled with blood. Nothing unusual in the appearance of the brain, except the effusion of serum between the membranes and into the lateral ventricles of the brain. Structures of the brain and medulla oblongata appeared to be normal. Coagulated blood in the longitudinal and lateral sinuses. The appearance of the brain is represented in Plate No. LII.[2] after the removal of the dura mater.

[1] Omitted.

[2] Omitted.

Thorax; Lungs. — Numerous old adhesions; otherwise healthy.

Heart. — Pale, and of a brownish yellow color. Fibrous concretions of golden color on both sides of heart, and one clot extended into the aorta for several inches, and was free from colored blood corpuscles. Pericardium contained several fluid ounces (about f℥v.) of golden-colored serous fluid.

Abdominal Cavity. — Liver of a brownish-yellow color, with distinct lobules, the lobuli being of a brownish-yellow color, and surrounded by a border of purplish blood-vessels. The liver was cirrhosed, and cut like fibrous substance under the knife, and the lobules started out from the cut surface. This cirrhosis appeared to have been of months' if not of years' standing, and had, perhaps, little or nothing to do with the disease and death of the patient.

Spleen. — This organ was enlarged about three times the natural size, and somewhat softened.

Alimentary Canal; Stomach. — This viscus presented no special derangement, and contained, as usual, much thin bilious matter mixed with the food.

Small Intestines. — The mucous membrane of the intestines presented a grayish and bluish mottled appearance, and was softened, and evidently in a state of gangrene.

The colon and rectum were extensively ulcerated, and were in a state of gangrene, and presented a lead gray and bluish color. This case was examined six hours after death, so that these gangrenous marks in the intestinal tract were evidently not post-mortem changes.

Examination of Stump. — The gangrenous stump was carefully examined and dissected. The tissues above the seat of the gangrene, up to the junction of the thigh with the trunk, were extensively swollen and infiltrated with serum. I dissected out the femoral vein, and found it filled with a firm clot of coagulated blood, which was readily drawn out for several inches in length towards the seat of the disease. The gangrene did not extend into the structures more than an inch or two from the wound.

Commentary. — The following facts are worthy of note in this case: —

Commentary.

1. The gangrenous state of the intestines. This state, as shown by previous autopsies, was not peculiar to those who had died with gangrenous wounds, but was found in those who never had gangrene in any external wound, and who had no abrasion upon the surface.

2. The coagulation of the blood in the heart and in the veins leading to the gangrenous wound.

It is worthy of note, that in those cases in which gangrene existed in the wounds or in the bowels, clots were found in the

heart and in the sinuses of the brain, and in the blood-vessels of the diseased limb, whilst in those cases in which no gangrene existed, as a general rule, no coagula were found, the blood being uncoagulated, fluid, and watery.

Case LIX. Illustrating the nature of the hospital gangrene of Andersonville.

Case LIX. Calwell, Federal prisoner. Confederate States Military Prison Hospital, Andersonville, Georgia. Death resulting from obstinate diarrhœa and dysentery, and supervening gangrene, September, 1864.

Autopsy, *Four Hours after Death.* — *Exterior.* — Great emaciation.

Head. — The brain presented the usual appearance. Serous effusions between the membranes and into the lateral ventricles in considerable quantities. Structure of brain otherwise healthy. No unusual congestion of blood-vessels. The appearance of the brain is represented in Plate No. LII.[1]

Thorax. — Heart pale, anæmic. When cut, the muscular structure of the heart presented a pale reddish brown color. The general appearance presented by the heart in this case, and in fact in all the Federal prisoners examined after death, is represented in the sketch, Plate No. LII. Fibrous clots in right side of heart. Pericardium filled with golden-colored serum.

Lungs. — Healthy. Several old adhesions.

Abdominal Cavity. — Liver of a purplish and yellowish mottled color. Lobules distinct. Cut surface more yellow than usual. Structure firm. Cirrhosis commencing. Spleen slightly enlarged, but healthy. Kidneys pale, but healthy.

Alimentary Canal. — Stomach appeared healthy, and was not unusually congested.

Small Intestines. — Greatly congested in patches, and the mucous membrane appeared thickened and softened. Glands of Peyer and solitary glands neither enlarged nor softened, and not more congested than the surrounding mucous membrane.

Large Intestine. — Mucous membrane of colon and rectum of a greenish grayish black color, ulcerated and gangrenous. The ulcerations were almost entirely black in color. The gangrene was confined almost entirely to the ulcerated colon and rectum. The gangrene of the large intestine in this case evidently preceded death, and was not a post-mortem change.

From the preceding observations upon the hospital gangrene of Andersonville, we draw the following general conclusions: —

General conclusions drawn from

1. Scurvy, arising from sameness of food and imperfect nutrition, caused directly or indirectly nine tenths of the deaths amongst the Federal prisoners at Andersonville. From

[1] Omitted.

the sameness of the food, and from the action of the poisonous gases in the densely crowded and filthy stockade and hospital, the blood was altered in its constitution, even before the manifestation of actual disease. In both the well and sick the red corpuscles were diminished; and in all diseases uncomplicated with inflammation, the fibrinous element was deficient. In cases of ulceration of the mucous membrane of the intestinal canal, the fibrinous element of the blood appeared to be increased; whilst in simple diarrhœa, uncomplicated with ulceration, and dependent upon the character of the food and scurvy, it was either diminished or remained stationary. The fibrin was increased in the cases of hospital gangrene. In cases of this disease in the extremities, and in cases of gangrene of the intestines, heart clots and firm coagula were universally present. The presence of these clots in the cases of hospital gangrene, whilst they were absent in the cases in which there were no inflammatory symptoms, appears to sustain the conclusion that hospital gangrene is a species of inflammation (imperfect and irregular though it may be in its progress), in which the fibrinous element and coagulability of the blood are increased, even in those who are suffering from such a condition of the blood, and from such diseases as are naturally accompanied with a decrease in the fibrinous element.

the preceding observations upon the hospital gangrene of Andersonville.

2. A scorbutic condition of the system appeared to favor the origin of foul ulcers, which frequently took on true hospital gangrene. Scurvy consists not only in an alteration in the constitution of the blood, which leads to passive hemorrhages from the bowels, and the effusion into the various tissues of a deeply colored fibrinous exudation, but, as we have conclusively shown by post-mortem examinations, this state is also attended with profound alterations in the appearance and consistence of the muscles of the heart and of the mucous membrane of the alimentary canal, and of the solid parts generally. We have, according to the extent of the deficiency of certain articles of food, every degree of scorbutic derangement, from the most fearful depravation of the blood and the perversion of every function subserved by the blood, to those slight derangements which are scarcely distinguishable from a state of health.

3. The fact that hospital gangrene appeared in the stockade first, and originated spontaneously without any previous contagion, and occurred sporadically all over the stockade and prison hospital, was proof positive that this disease will arise wherever the conditions of crowding, filth, foul air, and bad diet are present. The

exhalations from the hospital and stockade appeared to exert their effects to a considerable distance outside of these localities. The origin of gangrene amongst these prisoners appeared clearly to depend in great measure upon the state of the general system, induced by diet, exposure, neglect of personal cleanliness, and by various external noxious influences. The rapidity of the appearance and action of the gangrene depended upon the powers and state of the constitution, as well as upon the intensity of the poison in the atmosphere, or upon the direct application of poisonous matter to the wounded surface. This was further illustrated by the important fact that hospital gangrene, or a disease resembling this form of gangrene, attacked the intestinal canal of patients laboring under ulceration of the bowels, although there were no local manifestations of gangrene upon the surface of the body.

4. Gangrenous spots, followed by rapid destruction of tissue, appeared in some cases in which there had been no previous or existing wound or abrasion; and, without such well-established facts, it might be assumed that the disease was propagated from one patient to another in every case, either by exhalations from the gangrenous surface, or by direct contact. In such a filthy and crowded hospital as that of the Confederate States Military Prison, of Camp Sumter, Andersonville, it was impossible to isolate the wounded from the sources of actual contact of the gangrenous matter; the flies swarming over the wounds, and over filth of every description; the filthy, imperfectly washed, and scanty rags; the limited number of sponges and wash-bowls (the same wash-bowl and sponge serving for a score or more of patients), were one and all sources of such constant circulation of the gangrenous matter, that the disease might rapidly be propagated from a single gangrenous wound. Whilst the fact already considered, that a form of moist gangrene resembling hospital gangrene was quite common in this foul atmosphere, in cases of dysentery, both with and without the existence of hospital gangrene upon the surface, demonstrated the dependence of the disease upon the state of the constitution, and proves in a clear manner that neither the contact of the poisonous matter of gangrene, nor the direct action of the poisoned atmosphere upon the ulcerated surface, is necessary to the development of the disease; on the other hand, it is equally well established that the disease may be communicated by the various ways just mentioned.

5. The unfortunate accidents which followed vaccination in certain cases, were referable chiefly to the scorbutic state of the

patients, and the tendency of all abrasions and wounds, however slight, to assume gangrenous ulceration.

6. In the depressed condition of these prisoners, and in the foul atmosphere of the military prison hospital of Andersonville, amputation did not arrest hospital gangrene; the disease almost invariably returned. Almost every amputation was followed finally by death, either from the effects of gangrene or from the prevailing diarrhœa and dysentery.

Nitric acid and local applications generally, in this crowded atmosphere, loaded with noxious effluvia, exerted only a temporary effect; the gangrene would frequently return with redoubled energy after its application; and even after the gangrene had been entirely removed by local and constitutional treatment, it would return and destroy the patient.

7. Great as the rate of mortality from hospital gangrene appears to be amongst these Federal prisoners, it was equaled by the mortality from this disease before its treatment was well known, and when, as in the present instance, the medical officers did not have the necessary medicines and diet.

CHAPTER SIXTH.

Treatment of Hospital Gangrene. — Measures for the Prevention of the Disease. — Importance of Ventilation in Hospitals. — Danger of crowding Wounded into Box Cars. — Value of Disinfectants. — Importance to Wounded Men of Good, Nutritious Diet, and Cleanliness of Person and Clothing. — Constitutional Treatment of Hospital Gangrene; Principles upon which this should be based. — The Indications in the Treatment of Hospital Gangrene; first, to remove the Patient from all Causes which depress the System and deteriorate the Blood; second, to eliminate the Deleterious Agent; third, to restore the System to such a Condition that Healthy Nutrition, Reparation, and Inflammation may take Place; fourth, to induce such Changes in the Injured Parts as will lead to a Complete Separation between the Diseased and Dead Structures; fifth, to destroy all Poisonous Matters in the Diseased Parts; sixth, the Stimulation of the Capillaries and Structures around the Seat of Local Disease to Healthy, Active, Inflammatory Action. — Value of Quinine, Tincture of Sesquichloride of Iron, and Alcoholic Stimulants in the Constitutional Treatment of Hospital Gangrene. — Importance of Concentrated and Nutritious Diet: Milk, Beefsteak, Mutton, Soft-boiled Eggs. — Local Treatment of Hospital Gangrene. — Importance of clearing out all Dead Gangrenous Masses and Tissues. — Value of Nitric Acid; Method of its Application. — Mode of using Poultices. — Stimulating Applications, Oil of Turpentine, Tincture of Iodine, etc. — Value of Arsenical Applications in the Treatment of Hospital Gangrene. — Testimony of Ancient and Modern Writers. — Various other Remedies: Sulphates of Copper, Zinc, and Iron; Acid Nitrate of Mercury, Nitrate of Silver, Chloride of Zinc, etc. — Testimony of Ancient and Modern Surgeons.

MEASURES FOR THE PREVENTION OF HOSPITAL GANGRENE.

The previous discussion indicates the best means of preventing the origin and spread of hospital gangrene.

THE observations upon the relations of insufficient food, fatigue, and the exhalations of crowded tents and hospitals, to the origin and spread of hospital gangrene, indicate at once, without further discussion, the best means for the prevention of the disease.

Importance of abundant supplies of animal and vegetable food, free ventilation, and cleanliness, to the wounded.

Abundant supplies of nutritious animal and vegetable food, free ventilation, with the largest possible supply of fresh air to each patient, with scrupulous cleanliness of the wounds, as well as of the person's clothing and bedding, and apartments of the wounded, are the great prophylactic measures against hospital gangrene. When this disease appears in a filthy or crowded hospital, a heavy responsibility rests upon the medical officers.

It would be far better after great battles, to scatter the wounded under sheds, and even under trees, than to crowd them into close tents and hospitals, or to transport them to a distance in close box cars. Unfortunately it has been deemed necessary, after several

great battles, to transport large numbers of wounded soldiers in close, badly ventilated box cars, hundreds of miles from the scene of action. In many instances the supply of water, and of rags suitable for dressing, was limited; the wounded men shut up in these hot, confined boxes suffered from thirst, and the unwashed, undressed, and filthy wounds emitted a foul stench which contaminated the entire atmosphere. The severest epidemics of hospital gangrene have appeared amongst the wounded subjected to these most favorable conditions for the origin and spread of the disease.

General observations upon the location and arrangement of hospitals for sick and wounded. Evil effects of locating hospitals in the heart of populous towns and cities.

Hospitals for the treatment of the sick and wounded should be located in elevated, well-drained, and well-watered and healthy situations, where the most perfect arrangements may be made for free ventilation and the removal of all excrementitious matters, and if possible without the bounds of large towns and cities, and the largest space compatible with military discipline and medical attendance should be allowed to the hospital buildings and wards and tents. In many of the large hospitals of the Confederacy the density of population exceeded that of London or New York; that is, it exceeded upon an average 200,000 per square mile, whilst in well-constructed hospitals it should not exceed 15,000 per square mile.

Thousands of valuable lives were sacrificed by the suicidal policy instituted upon an immense scale in the earlier periods of the war, of using hotels, warehouses, stores, churches, and colleges, in the heart of cities and towns, for military hospitals. In Richmond, Virginia, hotels and tobacco factories within the heart of the city, were, after fair trial, abandoned for hospital purposes, and commodious wards were erected at Chimborazo, Camp Winder, and Camp Jackson, and Howard's Grove, and it is no exaggeration to say that thousands of lives were saved by this change. The value of well-constructed hospitals in the country was clearly shown, even in Georgia, which State up to the last twelve months of the war was not the seat of any very extensive or active military operations. Thus, the ratio of deaths from pneumonia was, in the Floyd House Hospital, Macon, Georgia, during thirty months, 22.9 per cent., or one death in 4.3 cases; in General Hospital No. 1, Savannah, Georgia, during twenty-five months, 31.35 per cent., or one death in 3.18 cases; in General Hospital No. 2, Savannah, Georgia, June, 1862, to July, 1864, 23.14 per cent., or one death in 4.32 cases; whilst in Guyton Hospital, situated some twenty

miles from Savannah, in a healthy, sandy, pine-barren region, the deaths from pneumonia were only 8.98 per cent., or one death in 11.14 cases.

A similar difference existed in the mortuary statistics of the other diseases and gunshot wounds. The excess of mortality in the general hospitals of Savannah and Macon, Georgia, over that of Guyton, was clearly referable in great measure to the hygienic conditions and relative locations of the various hospitals. In the earlier periods of the war, the chief surgeon of the Department of Georgia, Dr. H. V. M. Miller, at one time seriously contemplated breaking up all the general hospitals, with the exception of the well-constructed and salubriously located hospital at Guyton, and perfecting and enlarging the field, regimental, and division hospitals. When General Robert E. Lee commanded the Department of South Carolina, Georgia, and Florida, the propriety of establishing large hospitals in the elevated primitive regions of South Carolina and Georgia, immediately above the extensive eocene plain reaching to the Atlantic and Gulf of Mexico, as at Aiken, South Carolina, and the sand-hills near Augusta, Georgia, was debated.

In the crowded hospitals, the simplest diseases assumed malignant characters; the typhoid poison altered the course of mumps, and measles, and pneumonia, and was the cause of thousands of deaths; and the foul exhalations of the sick poisoned the wounds of healthy men, and induced erysipelas, pyæmia, and gangrene. Who can estimate the suffering inflicted, as in the celebrated case of the Augusta hospitals, by the development and spread of hospital gangrene in overcrowded hospitals situated in the heart of towns and cities?

The wounded should never be placed in wards with patients suffering from any one of the contagious or infectious diseases.

As a rule in military practice, the wounded should never be placed in wards with patients suffering from any one of the contagious or infectious diseases, as small-pox, measles, scarlet fever, typhus fever, typhoid fever, erysipelas, pyæmia, or hospital gangrene; and these various diseases should not be indiscriminately mingled together. The voice of the profession is unanimous as to the exclusion and isolation of small-pox, but we know from extended experience that sufficient care was not exercised in the isolation of the other diseases.

Relative value of tents

A diversity of opinion existed amongst the Confederate surgeons as to the relative value of tents and wooden hospitals. After careful examination, we were led to prefer the

permanent wooden structures for the treatment of both sick and wounded; at the same time it must be admitted that the sudden emergencies of the recent war necessitated the employment of tents to a great extent. Theoretically a tent admits air on all sides, but practically the occupants in cold or rainy weather exclude the external air, and that within rapidly becomes vitiated by respiration and the emanations from the sick. When the tent is not carefully floored with boards, exhalations take place from the damp soil, especially in wet weather, and the earth becomes a convenient receptacle of filth of all kinds. In profuse suppurations, the nurses and patients frequently allow the discharges to saturate the ground, and when this dries, the dust blown about by the wind or stirred up in sweeping becomes a serious vehicle for the propagation of pyæmia and hospital gangrene. Properly constructed wooden hospitals, on the other hand, allow of regular cleansing, disinfection, and whitewashing, and afford more regular supplies of fresh air and of light, as well as greater facilities for the regulation of the temperature and the moisture.

and wooden hospitals in military service.

In general hospitals, each seriously wounded man should be allowed, if possible, two thousand cubic feet of air; the severest cases should be distributed uniformly amongst the lightest cases, and each ward should be thoroughly evacuated, cleansed, whitewashed, and fumigated with chlorine or sulphurous acid at least every two weeks, or oftener if possible. A continuous rotation should thus be kept up throughout the wards of large hospitals, and during the period of cleansing the windows and doors should be left open for two or three days. The floors should be cleansed with a solution of chlorinated soda, or of carbolic acid. The most efficient and economical agent in disinfection is sulphurous acid, which may be readily generated by the combustion of sulphur. As the gas is irrespirable, the occupants should be removed from the ward; and to insure the destruction of the vermin, decomposing organic matter, and *materies morbi*, the windows and doors should be closed, the gas should be evolved in large quantities, and the bedding and clothes subjected to the action of its fumes. It is well established, that fumigations with chlorine are also highly efficacious in purifying the wards of hospitals. In the present state of the Confederacy, however, it is almost impossible to command the necessary supplies of the mineral acids. The best indigenous substitute which has fallen under my observation is the tar fumigation; in the tar smoke, carbon in a highly

Hygiene of military hospitals. Disinfectants. Cleansing lotions.

divided state, together with various disinfecting empyreumatic matters, are the active agents which purify the infected atmosphere of the crowded hospital. After an extended use of tar fumigations in military practice, I found that this smoke, so far from irritating the lungs, appears to act beneficially upon pulmonary complaints.

For the absorption of noxious gases, and for the arrest of decomposition in the fæcal and urinary matters in the bed-pans and privies of hospitals, a long list of substances might be given, but the most efficient and readily attainable are charcoal, sulphate of lime, sulphite of lime, chloride of lime, protosulphate of iron, and coal-tar. The two latter, namely, coal-tar and sulphate of iron, form most valuable disinfectants in the bed-pans, water-closets, and privies. The coal-tar should be used freely about the privies, water-closets, and drains, when it can be obtained. The lime of the gas-works also acts as a valuable disinfectant.

The straw of the bedding should be frequently renewed, the old straw burned, and the bed sacks boiled in water, to which a portion of permanganate of potassa has been added.

Importance of attention to the personal cleanliness of the wounded.

The most scrupulous attention should be paid to the personal cleanliness of the wounded. When from the nature of the wound the patient cannot be thoroughly washed at stated intervals, great benefit may be derived by sponging off the entire body with the following disinfecting, stimulant, and cleansing lotion: —

℞. Labarraque's solution of hypochloride of soda, f℥ii.; tincture of camphor, f℥ss.; whiskey, f℥ii.; common salt, ℥i.; water, f℥xvi.

In military practice I have derived great benefit from the use of this lotion, not only in severe cases of gunshot wounds, but also in typhoid and low forms of fever. This lotion effectually removes the greasy sweat from the skin, and all filth, and imparts a clean, wholesome smell, which refreshes the patient. The free use of Labarraque's solution of hypochloride of soda, or of a solution of permanganate of potassa, to all serious wounds, will not only add to the comfort of the patients, and promote the healing of the wounds, but it will also tend to prevent the origin and spread of hospital gangrene. When Labarraque's solution cannot be obtained, a weak solution of nitro-muriatic acid, in the proportion of one ounce of the acid to a gallon of water, will make a useful disinfecting and slightly stimulating wash for wounded surfaces, especially when the granulations are tardy. This solution should be prepared fresh each morning, and the wounds should be carefully washed with it when necessary, at least morning and evening.

The healing of ill-conditioned and unhealthy wounds may also be promoted by combining tincture of iodine and carbolic acid with the simple cerate used in dressing. I have found the following formula of great value in the treatment of gunshot wounds: —

℞. Tincture of iodine, f℥i.; carbolic acid (pure crystallized), ʒiii.; tincture of opium, f℥iv.; simple cerate, ℥xii.; mix; use as an ointment to the diseased surface. The tincture of iodine and carbolic acid may be increased two or three fold, if necessary, in the more unhealthy wounds. This ointment fulfills a useful purpose, in that in addition to its stimulant and cleansing action, it drives off effectually flies and other insects from the neighborhood of the wound.

The greatest attention should also be paid to the cleanliness of the clothing of the wounded, and to the dressings of the wounds.

The clothing should always be boiled in water containing a portion, if possible, of permanganate of potassa; the boiling temperature can always be commanded, and should never be neglected, as by this means we coagulate, alter, and destroy the decomposing poisonous organic matters.

The dressings from the wounds, and the soiled clothing, should never be allowed to accumulate about the hospital.

The only safe rule for the prevention of hospital gangrene is to burn and destroy all materials which have been used in dressing wounds. Even when the lint and rags have been carefully washed and boiled, they may still act deleteriously upon the diseased surfaces.

All materials used in dressing wounds should be burned or destroyed. Lint and rags may be the medium of communicating gangrene and pyæmia.

Professor Brugmans, as quoted by Guthrie, in his "Commentaries on the Surgery of the War in Portugal, France, and the Netherlands," says that in 1797, in Holland, charpie, composed of linen thread cut of different lengths, which, on inquiry, it was found had been already used in the great hospitals of France, and had been subsequently washed and bleached, caused every ulcer to which it was applied to be affected by hospital gangrene.

Finally, each patient should be supplied with his own wash-basin and sponge and towel, which should be regularly cleansed, and kept scrupulously clean.

CONSTITUTIONAL TREATMENT OF HOSPITAL GANGRENE.

Inflammation in the healthy system is a reparative process of nature, and should be studied and treated as a modification of the natural processes concerned in the preserva-

General principles which should guide

the constitutional treatment of hospital gangrene.

tion of the body; or, in the language of John Hunter, "Inflammation in itself is not to be considered as a disease, but as a salutary operation consequent either to some violence or some disease;" it is "only a disturbed state of the parts, which require a new but salutary mode of action to restore them to that state wherein a natural mode of action alone is necessary."

When a foreign body is thrust into the living tissues, the delicate capillaries are broken up, the mutual relations of the forces are disturbed, the nerves are injured in such a manner as no longer to be capable of exerting their normal influence. If the foreign body be immediately withdrawn, and if the animal wounded be in a state of perfect health, that is, with a proper constitution of blood and structures, and a proper correlation of the forces, the blood, and especially the coagulable lymph, may close up the wound; and with the exception of pain, and of a temporary congestion of the surrounding parts, from the obstruction of the circulation in the injured capillaries, thus forcing more blood around the injured part, as well as from the disturbance of the nervous force, and of the processes of nutrition in the surrounding capillaries, no other phenomena are manifested. The effused fibrinous matter endowed itself with life, and surrounded by living tissue, and subjected to the influences of living tissue, passes through various changes, which resemble the changes in normal nutrition, secretion, and development, and which result in development and repair.

If, on the other hand, the structures are too much injured to be repaired in this manner, the same disturbances and the same phenomena are manifested, but being increased in intensity, the changes in the nutrition of the injured part progress to correspondingly greater effects. The same effusion, and the same reparative processes, are active in the one case as in the other, but in the latter the dead tissue acts as a foreign body, and must be removed, and a process instituted by which its place may be supplied by other matter. As the matter effused and the injured tissue possess a definite chemical constitution, and are related by definite affinities to the surrounding forms of matter, and as they are subjected to the action of fixed forces exciting and controlling the nutrition and circulation of the surrounding parts, the products will, to a great extent, be uniform in the healthy organism.

When, on the other hand, a mechanical injury is inflicted upon an animal whose forces are depressed, and the nutritive elements of which are deficient in quantity and quality, the process of re-

pair will be correspondingly retarded, and the products will be correspondingly altered from those formed in the healthy organism.

If the system be under the influence of some disturbing agent, as a poison, at the time of the reception of the injury, the characters of the inflammatory process will manifestly depend upon the affinities of the extraneous substance or poison, for the elements of nutrition, and upon its power to disturb the nutrition, secretion, excretion, and the nervous and muscular forces.

In the case of a poison acting in the blood, its local and inflammatory effects will be chiefly manifested in that organ for which it has the greatest affinity, or in the nutritive processes of which it produces the greatest disturbance; and as the most essential changes of the blood take place in the capillaries, it is in these parts that we must look for the chief disturbances. In this case, the effects of inflammation may be widely extended, not only by the reflection of the local disturbances to other parts through the nervous system, but also by the entrance into the circulation of certain products of inflammation which will be capable of inducing changes in the mass of the blood, and in the nutrition and secretion of various organs.

In this last form of inflammation, when, in addition to the local injury, we have a poisoned condition of the blood, and of the structures involved in the local inflammation, the manifest indications from the principles just laid down are, —

Indications to be fulfilled in the treatment of hospital gangrene.

First. To remove the patient from all causes which tend to depress the system, and especially from those causes which are known to have been directly and specially active.

Second. To eliminate the deleterious agent.

Third. To restore the system to such a condition that healthy nutrition, reparation, and inflammation may take place.

Fourth. To induce such changes in the injured parts themselves as will lead to a complete separation between the diseased and dead structures.

Fifth. To destroy all poisonous matter in the diseased parts.

Sixth. After the removal of the dead parts, and after the destruction of all contagious elements capable of disseminating the disease to the surrounding tissues, to stimulate the capillaries and absorbents around the local injury to such healthy, active, inflammatory action, as will result in the development of healthy granulations. The three last indications will be considered under the head of the local treatment.

Isolation and free ventilation the first and most essential measure in the treatment of hospital gangrene.

In the treatment of hospital gangrene, the first essential measure, without which the most enlightened system of treatment is comparatively valueless, and at best tardy in its action, is to remove the patient from the crowded wards, and secure for him in an isolated room or tent the largest possible supply of fresh air.

Importance of attending to the constitutional disturbances in hospital gangrene.

We have seen that the constitutional symptoms in most cases of hospital gangrene hold a prominent place. The dejected spirits, the depressed state of the nervous system, the small, accelerated pulse, the feeble, sluggish, capillary circulation, and the depressed state of the temperature in the extremities, all point to the supporting tonic and stimulating plan of treatment as the rational system.

Therapeutic indications. Supply of elements of healthy blood and nutrition.

The therapeutic indications are to furnish the elements of healthy blood, and of active nutrition, secretion, and repair, to excite and support the vital powers, and to allay nervous irritability. These intentions are best fulfilled by resorting to combinations of tonics and anodynes after the morbid secrétions of the bowels have been evacuated by gentle purgatives or enemata.

Emetics and purgatives.

In many cases emetics may be used with advantage; and it will always be found best to evacuate the constipated bowels by a purgative. From eight to ten grains of blue mass or calomel, followed with castor-oil in four or six hours, will generally accomplish the desired result. The compound cathartic pill of the United States pharmacopœia also answers this indication equally well in most cases.

The subsequent tonic and supporting plan of treatment will prove far more certain and beneficial in its action after the portal system has been unloaded, and the bowels cleared of morbid secretions. Throughout the treatment the bowels should be kept open by the compound cathartic pill at bed-time, or by salines, as the Seidlitz powder, in the morning.

Blood-letting to be avoided.

Blood-letting should, as a general rule, be avoided, as tending still further to depress the enfeebled powers, and as tending to inflict a wound which in turn may become gangrenous.

Quinine and tincture of the sesquichloride of iron important and efficient remedies.

Quinine and the tincture of the sesquichloride of iron deservedly hold a high place in the estimation of Confederate surgeons, in the treatment of hospital gangrene. In cases of ordinary severity, three grains of quinine and fifteen drops of the tincture of the sesquichloride of iron,

administered three or four times a day, will be found to be sufficient, in conjunction with the other measures, to induce a marked and rapid improvement in those patients properly isolated and ventilated. When the ravages of the disease are extensive, and the danger of extensive and exhausting hemorrhage great, the amount of the tincture of the sesquichloride of iron may with benefit be increased to twenty drops, every two or three hours. The mercurials should not be given at the same time with the tincture of iron, from the well-known danger of generating corrosive sublimate by the combination. The tincture of the sesquichloride of iron should be temporarily suspended during the administration and action of mercurials.

When troops have been exposed to malaria, the accompanying fever of hospital gangrene will frequently partake of an intermittent and remittent character; and in such cases the quinine may be freely administered, in an average dose of five grains, three or four times during the twenty-four hours; but as far as my experience extends, in cases uncomplicated with malarial fever, quinine in large doses exerts no beneficial effects upon the progress of the constitutional and local symptoms. The best effects will be obtained with the small doses indicated above.

Huxham's tincture of bark (tinctura cinchona composita), administered in full doses, varying from one fluid drachm to half a fluid ounce, every three or four hours, fulfills in this disease important indications as a stimulant, diuretic, and elegant stomachic cordial.

Huxham's tincture of bark.

The sesquichloride of iron may, with advantage to the patient, be administered in combination with chlorate of potassa, in the proportion of from ten to twenty drops of the former and five to fifteen grains of the latter, dissolved in four ounces of water. This dose may be repeated every two, three, or four hours. Whilst we are unable to explain the exact manner in which chlorate of potassa acts upon the system, still it is well established that it proves highly beneficial in those complaints in which a depraved state of the solids and fluids shows itself by malignant typhoid symptoms, and a disposition to phagedænic ulceration and gangrene. The combination of this salt with sesquichloride of iron is especially valuable from the liberation of some chlorine and hypochlorous acid.

Combination of chlorate of potassa with the tincture of the sesquichloride of iron.

The following formula has proved useful in the treatment of hospital gangrene and other diseases of an asthenic typhoid character in my hands: —

℞ Tincture sesquichloride of iron, f℥i.; chlorate of potassa, ℥iv.; sulphate of quinia, ℥ii.; hydrochloric acid, f℥i.; distilled water, f℥ii. Dissolve the chlorate of potassa in the distilled water, add the hydrochloric acid, and then dissolve the quinine in this acid mixture, and finally mingle this solution with the tincture of iron. Dose, thirty to sixty drops, in wine-glassful of sweetened water (sucked through a quill), three or four times a day.

Hydrochloric and nitric acids.

Hydrochloric and nitric acids, singly or combined, exert beneficial effects in some cases. Wherever they are indicated, the sesquichloride of iron, or the combination of this salt with chlorate of potassa, will answer an equal if not better purpose, except when there is jaundice and marked torpidity of the liver, in which case the nitro-muriatic acid may be employed both internally and externally in the form of the nitro-muriatic acid bath.

These acid mixtures should not be continuously employed for more than two or three weeks at any one time, as in some cases the coats of the stomach appear to suffer from their prolonged action. When it is necessary to intermit the tincture of the sesquichloride of iron and the mineral acids, we have found the following formula of great value as tonics in hospital gangrene, ill-conditioned wounds, and profuse suppurations: —

Other combinations of iron and quinine.

℞ Tartrate of iron and potassa, ℥i.; tartaric acid, ℥ii.; sulphate of quinia, ℥ii.; distilled water, f℥xii. Dissolve the tartaric acid in the water, and add the quinine and then the tartrate of iron and potassa. (Shake well before using.) Dose, table-spoonful in wine-glassful of water three times a day.

In some cases, when it is desirable to overcome the astringent effects of the iron and keep up a gentle action on the bowels, the following combination is valuable: —

℞ Strychnine, grains ii.; sulphate of quinia, ℥ii.; precipitated iron (iron by hydrogen), ℥iii.; extract of rhubarb, ℥ii. Mix; divide into one hundred pills; sig. one pill three times a day. A mixture of equal parts of the phosphates of lime and iron, administered in doses of from ten to twenty grains in a glass of fresh milk, three times a day, is an admirable and efficient tonic, and strengthens the digestive powers, whilst it enriches the blood.

Remedies for hospital gangrene when engrafted upon constitutional syphilis or scrofula.

When gangrene attacks a patient suffering with constitutional syphilis or scrofula, iodine, iodide of potassium, and iodide of iron should be freely used. The following mixture will fill the important indications of acting both as a tonic and alterative: —

℞. Syrup iodide of iron, f℥i.; tincture of iodine, f℥ii.; iodide of potassium, ℥ii.; syrup of ginger, f℥vi.; distilled water, f℥i. Dissolve the iodide of potassium in the distilled water, and add the tincture of iodine, and then mingle with the syrups of iodide of iron and ginger. Dose, tea-spoonful in wine-glassful of water, three times a day.

The arsenical solution (Fowler's solution arsenite of potassa) has been employed with benefit in some cases.

Arsenical solution.

Oil of turpentine, camphor, musk, and warm aromatics and spices, frequently prove beneficial, and may be administered in various forms of combination. The stimulant and depurant effects of the oil of turpentine appear to be of some value in the treatment of hospital gangrene. To obtain decided effects upon the capillary circulation, in the debilitated state of the system in this disease, the oil of turpentine should be administered in full doses at short intervals of time. So slow is the system to respond to stimuli in hospital gangrene, that I have known this remedy to be given in tea-spoonful doses, at regular intervals, without any marked effects upon the kidneys or bladder, as far as the production of strangury or bloody urine. It is, however, a question whether these large doses, especially if they be continued for a great length of time, may not lay the foundation of disease of the kidneys and bladder.

Oil of turpentine, camphor, musk, and aromatics.

Opiates are indispensable in the treatment of almost every case of hospital gangrene during the active stages, and should be administered freely, to allay irritability, and to produce sleep, and to check excessive discharges from the bowels.

Opiates indispensable in the treatment of hospital gangrene.

The diarrhœa which frequently complicates the worst cases of hospital gangrene, is the result of derangement of the alimentary canal, consequent upon the febrile action and the absorption of the poisonous matters from the diseased gangrenous tissues. The tincture of the sesquichloride of iron appears to exert a beneficial effect in such cases, especially when opium is freely used. As this diarrhœa in many cases partakes of the nature of a critical discharge, it should not be suddenly checked. In camp life, the soldier is liable to chronic diarrhœa and dysentery, and in military practice we should never lose sight of the fact that the diarrhœa attending gunshot wounds may have had its origin in a deranged state of the intestinal mucous membrane preceding the reception of the wound or the supervention of gangrene.

Treatment of the diarrhœa accompanying hospital gangrene.

Subnitrate of bismuth, in doses of from twenty to forty grains, combined with from three to five grains of Dover's powder, every three or four hours, is perhaps one of the most valuable remedies in this class of diseases. The exclusive use of milk as a diet should be insisted upon in these cases. When the diarrhœa arises manifestly from the absorption of the gangrenous matters, the subnitrate or the carbonate of bismuth should be combined with finely divided charcoal.

When it is necessary to control the diarrhœa by astringents, the following formula has proved useful: —

Astringent mixture for diarrhœa.

℞. Tincture kino, f℥ii.; tincture catechu, f℥iii.; camphorated tincture of opium, f℥i.; precipitated carbonate of lime, f℥ss.; Huxham's tincture of bark, f℥vi. Mix. (Shake well before using.) Dose, table-spoonful diluted with four parts of water, every three or four hours.

When there is ulceration of the large intestines, nitrate of silver administered internally, in combination with opium, and also by the rectum in solution, is a well-known and standard remedy.

The DIET throughout the course of hospital gangrene should be as highly nutritious and nitrogenized as possible, and should consist chiefly of concentrated animal soups, soft-boiled eggs, egg-nog, milk-punch, etc., with a liberal supply of vegetables and ripe fruit, if they can possibly be obtained.

Diet highly nutritious.

ALCOHOLIC STIMULANTS. — Good brandy, whiskey, and wine, or porter, administered in moderate quantities, at short intervals, will prove highly beneficial in almost all cases. I have witnessed the most decided benefit from the careful but liberal use of alcoholic stimulants in hospital gangrene, and never in a single instance had occasion to regret their use.

Alcoholic stimulants.

LOCAL TREATMENT OF HOSPITAL GANGRENE.

Whether we regard the local affection as a poisoned wound, in which contagious poisonous matters are continually generated, and from which the surrounding living tissues are contaminated; or look upon the destruction of the tissues as the result of deficient and perverted inflammatory action, the principles of the local treatment would in either view be much the same.

Pathological and therapeutical principles which should govern the local treatment of hospital gangrene.

If the first view be held, our efforts should be directed to the alteration, destruction, and complete removal of the dead and poisonous matters and tissues.

If the second view be accepted, the manifest duty of the physi-

cian would be to use such measures as will increase the vital power of the tissues and vessels, and enable them to form coagulable lymph, by which the disorganization will be circumscribed and arrested.

These indications are best fulfilled by the liberal and thorough application of concentrated nitric acid to the gangrenous parts. In this application, it is desirable that the nitric acid should not merely coagulate and alter completely the gangrenous matters, but also come in contact with the sound parts, and by its action upon the fluids and surface of the exposed parts, stimulate the living structures into a new form of inflammatory action, which will cause the complete separation of all the dead parts, the arrest of the further progress of the disease by the more exalted condition of the sound parts, and by the effusion of healthy coagulable lymph, and the establishment of the process of repair. In most cases, especially when the patient has been properly isolated, one thorough application of nitric acid will be sufficient, if followed by the necessary constitutional and local treatment. If, however, the patients be retained in the crowded wards or tents, the most energetic treatment will fail entirely of arresting the disease.

Concentrated nitric acid in the local treatment of hospital gangrene. Method of application, effects of, etc.

As this is a painful procedure, the patient as a general rule should be placed under the influence of chloroform and sulphuric ether. During the insensibility of the patient, the surgeon should carefully examine the wound, and first remove all the gangrenous tissues, using the scalpel and scissors, and causing the parts beneath to bleed quite freely. All sinuses formed under the skin, or between the muscles, or in the cellular or areolar tissue, must be freely laid open, and the dead tissues removed. The entire wound is then to be carefully wiped out with a sponge or dry lint, and the concentrated acid applied with a brush or mop to the entire surface; and care should be taken that the acid penetrate into all the sinuses and cavities. If any diseased part be untouched or undestroyed by the acid, the disease will recommence and spread from that point.

After extended observation, I am convinced that the failures with the nitric acid amongst the Confederate wounded were attributable mainly to the neglect of the careful cleansing of the wounds, and the failure in applying the acid freely and thoroughly to the diseased surfaces.

The acid destroys the contagious properties of the gangrenous matter, and converts the diseased surface into that of a simple wound or ulcer; and in many cases the pain and constitutional

symptoms are entirely removed by the destruction of the diseased surface.

After the entire surface of the wound has been thoroughly mopped with the nitric acid, the subsequent treatment will consist in —

The careful removal of all dead masses; the application of stimulating poultices; the systematic and thorough cleansing of the wound at stated intervals with water, and with solutions of chlorinated soda, permanganate of potash, nitro-muriatic acid, acetic acid, carbolic acid, and pyroligneous acid. After the application of the nitric acid, the parts should be covered with flaxseed, meal, hop, or charcoal poultices, rendered antiseptic and stimulating, with turpentine, camphorated tincture of opium, tincture of bark, tincture of camphor, pyroligneous acid, creosote, or carbolic acid.

Subsequent treatment, after the application of nitric acid as a caustic to the gangrenous wound. Disinfectant and stimulating applications. Chlorinated soda, permanganate of potassa, nitro-muriatic acid, acetic acid, carbolic acid.

The prompt removal of all detached masses of tissues, and the thorough washing away of all morbid secretions, are most important measures to prevent the recurrence of the disease, and to secure the establishment of healthy inflammatory action. Whenever a circumscribed portion of the wound looks unhealthy and gangrenous, the nitric acid should be applied directly to the diseased parts, care being taken that the sound parts be not unnecessarily subjected to its action.

In many cases, before the wound assumes a healthy condition, instead of applying poultices daily (a poultice being always applied immediately after the application of the nitric acid to shield the sound parts and promote the casting off of the dead tissues), it is preferable to fill the cavity of the wound with lint or cotton saturated with various stimulating fluids, as a weak tincture of iodine, oil of turpentine, tincture of camphor, tincture of Peruvian bark, pyroligneous acid, or a solution of carbolic acid.

When there is danger of hemorrhage, either from large vessels or from the general surface of the wounds, lint saturated with the undiluted tincture of the sesquichloride of iron, or with a solution of the persulphate of iron, should be applied. It may be laid down as a general rule, that ligation or amputation should not be resorted to in cases of hemorrhage in hospital gangrene, until these efficient styptics have been freely applied to the bleeding surfaces. Of course hemorrhage from large arteries should be arrested, if possible, by ligation, but in hospital gangrene the sloughing of large arteries accom-

Tincture sesquichloride of iron as a local application and styptic, for the arrest of hemorrhage.

panied with hemorrhage is usually fatal. The operation of ligating arteries does not succeed in hospital gangrene, unless the local disease has been first arrested, and the patient has been separated from all others suffering with it, and subjected to the best hygienic and dietetic measures.

As a rule, no amputations, no matter what be the condition of the wounds, whether gangrenous or healthy, should be performed in the wards of a hospital in which gangrene is prevailing. Such practice is as reprehensible as the careless distribution of healthy and fresh wounds amongst the gangrenous wards. When amputation is unavoidable, the patients, whether the wound be gangrenous or not, if the disease be present in the hospital, should be isolated as far as possible, and every attention paid to proper ventilation, cleanliness, and diet. Amputation is rendered necessary in hospital gangrene under certain circumstances, as when a large joint is exposed; when the gangrenous wound is of great size, and the muscles, nerves, and blood-vessels and bones are extensively exposed, and the constitutional powers are undermined by the absorption of the gangrenous matter and the incessant suffering; and when large blood-vessels are destroyed by the destructive action, and there is danger of death from hemorrhage. In some cases, the surgeon gains an advantage by substituting by amputation a small, defined wound for a large gangrenous surface from which the entire mass of blood may be infected.

Amputation in hospital gangrene to be avoided.

After the appearance of healthy granulation and of laudable pus, the stimulating, astringent, and caustic applications should be abandoned, or only occasionally applied with caution, and the wound should be treated as any other simple granulating ulcer. The carbolic acid cerate mentioned under the head of the measures for the prevention of the disease, may be advantageously applied as a stimulating and antiseptic dressing, which will promote healthy suppuration and granulation, and at the same time prevent a recurrence of the disease.

After the appearance of healthy granulation and laudable pus, caustic applications must be abandoned, and the wound or ulcer treated as any other simple granulating ulcer.

The person of the gangrene patient should be kept scrupulously clean, and for this purpose the stimulating and cleansing lotion previously recommended should be freely and systematically used. Sponges should be discarded, all rags and dressings should be destroyed as soon as removed from the diseased parts, each patient should be provided with his own wash-bowl and towel, and a nurse should be provided for every five patients.

Person and clothing of gangrenous patients to be kept clean, and all soiled sponges, bandages, and lint to be destroyed.

Bed-sores.

The surgeon should never lose sight of the tendency to the formation of bed-sores in this disease. In the depressed state of the forces and the feeble state of the capillary circulation, pressure is ofttimes attended with death of the injured tissues. Gangrene frequently attacks these bed-sores, and I have seen instances in which death was directly traceable to the bed-sores. The proper measures, as equalized pressure, soft beds, and, above all, frequent changes of the position and stimulating applications to the surface, should be resorted to, in order to prevent this most distressing and unfortunate complication.

At all times the proper drainage of the wounds should receive most careful attention.

Permanent contraction of muscles and limbs from gangrene.

During the healing of gangrenous wounds great care is necessary to prevent permanent contractions of limbs. Under the best and most careful treatment, many limbs are permanently contracted under the action of this destructive disease.

Various other applications have been recommended and employed by Confederate surgeons, in the local treatment of hospital gangrene, as the actual cautery, sulphate of copper, persulphate of iron, nitrate of silver, and tincture of iodine. These remedies, without doubt, exert beneficial effects, as I have myself frequently witnessed. The method, however, which has just been given, as far as my observation extends, is the most efficient.

HISTORICAL NOTES UPON THE TREATMENT OF HOSPITAL GANGRENE.

Notes upon the method of treating foul ulcers by the ancients. Observations of Hippocrates upon the treatment of ulcers.

As we have before shown, Hippocrates was acquainted with foul, malignant, phagedænic, gangrenous ulcers. The Father of Medicine gave many valuable precepts upon the treatment of ulcers; thus he affirms that gentle purging of the bowels agrees with most ulcers, and in wounds of the head, belly, or joints, where there is danger of gangrene, in such as require sutures, in phagedænic, spreading, and in otherwise inveterate ulcers. Hippocrates directs that the ulcer is to be frequently cleaned with a sponge, and then a dry and clean piece of cloth is to be frequently applied to it, and in this way the medicine, which it is supposed will agree with it, is to be applied, either with or without a bandage.

The virtues of arsenic and copper,

Amongst the astringent and caustic substances applied by Hippocrates to ulcers, may be recognized many used at the present day in the treatment of hospital gangrene, as

arsenic, sulphates of iron and copper, acetate of copper, oxide and acetate of lead, carbonate of soda, and alum. The *caricum* of Hippocrates, used as a caustic application to foul gangrenous ulcers, was composed of black hellebore, sandarach, flakes of copper and lead, sulphur, arsenic, and cantharides.

In the treatment of ulcers, known to Hippocrates.

In the long list of remedies recommended by Pliny, in his "Natural History," for the treatment of foul phagedænic and gangrenous ulcers and wounds, many, as the blood and mashed flesh of dragons, toads, serpents, worms, and fish, appear evidently to have been recommended from superstitious notions rather than from any real therapeutic virtues; but we recognize many really powerful agents, as the salts of copper, iron, lead, and arsenic. The *sandarach* of Hippocrates, Pliny, and of the ancient physicians is the realgar of the moderns, red opiment or red sulphuret of arsenic. Pliny describes the sandarach as being found both in gold and silver mines. "The redder it is, the more pure and friable; and the more powerful its odor, the better is its quality. It is detergent, astringent, healing, and corrosive, but it is most remarkable for its septic properties. Applied topically with vinegar, it is curative of alopecy. It is also employed as an ingredient in ophthalmic preparations. Used with honey, it cleanses the fauces, and makes the voice more clear and harmonious. Taken with the food, in combination with turpentine, it is a pleasant cure for cough and asthma. In the form of a fumigation also, with cedar, it has a remedial effect upon those complaints."[1] In combination with the wild *astaphis*, Pliny recommends it as a local application for itch-scabs and prurigo, and also for the destruction of vermin; in combination with black hellebore and copper filings, it removes warts.[2]

Observations of Pliny on the treatment of ulcers.

The sandarach of Hippocrates, Pliny, and of the ancient physicians red sulphuret of arsenic.

The ashes of blood and of various plants, calcined shells and bones, as well as the excrements of various animals, recommended by Pliny as applications to ulcers, without doubt possess valuable properties from their alkaline and stimulant properties; and to this day the dung of domestic animals, especially of the cow and of the camel in Africa, is used by the Africans, both in their native country and in America, as an efficient poultice to boils, carbuncles, and phagedænic ulcers. The various admixtures of myrrh, frankincense, and balsams, and the

Value of certain ingredients entering into the formula of the ancients.

[1] Book xxxiv. chap. 55.

[2] Book xvii. chap. 47; book xxiii. chap. 13; book xxv. chap. 22; book xxviii. chap. 62.

astringent principles of certain plants, entering into the composition of the ointments recommended by Hippocrates, Pliny, and the older writers on medicine, without doubt exerted a most beneficial action upon unhealthy and foul ulcers, in virtue of their stimulant, astringent, and antiseptic properties. Bile of the beef, which entered into some of these local applications to ulcers, is used by the common people to the present day; and its virtues are probably due in part at least to its alkaline properties, and its tendency to arrest or modify certain forms of digestion and fermentation.

The various remedies recommended by Hippocrates of ancient origin.

The various remedies recommended by Hippocrates for the treatment of wounds and ulcers were most probably, even in his day, of ancient origin, being derived in part at least from the Egyptians and from the votive tablets in the temples of the Asclepiadæ; and the subsequent medical writers improved but little upon the formulæ of the Father of Medicine, and their most valuable remedies for the treatment of foul ulcers owed their virtues to the preparations of arsenic, alum, iron, copper, zinc, lead, mercury, and silver. It is evident that the discovery of many of these compounds was due to the labors of the miners and the workers in brass and iron and the precious metals; and even the actual cautery dates back even beyond the days of Hippocrates; and in such high repute was this method of arresting certain forms of disease with the Father of Medicine, that he placed it above all other remedies in power in his celebrated aphorism: "Those diseases which medicines do not cure, iron cures; those which iron cannot cure, fire cures; and those which fire cannot cure, are to be reckoned incurable." The surgeon of the present day might learn a valuable lesson from Hippocrates and the older writers as to the great value of wine as a local application in the treatment of ulcers.

The value of the prescriptions of subsequent writers due chiefly to the potent remedies recommended by Hippocrates.

In those portions of the writings of Galen, Oribasius, Aetius, Celsus, Actuarius, Nonnus, Octavius Horatianus, Scribonius Largus, Avicenna, Serapion, Averrhoes, Haly Abbas, Alsaharavius, Rhases, and Guido, which relate to the nature and treatment of putrid phagedænic and gangrenous wounds and ulcers, may be found frequent references to the potent remedies recommended by Hippocrates, namely, the actual cautery, copper, and arsenic.

The preparations of arsenic the

Without doubt the preparations of arsenic were the most potent of all the local applications employed by the ancients, and in modern times the attention of the profession has been

directed to the great value of this agent in hospital gangrene, by Surgeon H. Home Blackadder, in his valuable "Observations on the Phagedæna Gangrænosa." The experience of this author is worthy of careful consideration, and we extract his observations upon the use of arsenic: —

most potent of all the local applications employed by the ancients in the treatment of foul ulcers.

"Fowler's solution of arsenic is a medicine which is furnished to hospitals on foreign stations, on account of its well-known good effects when used internally in cases of inveterate intermittent fever. Its employment as an external application was certainly never intended; yet, if too strong for that purpose, it could readily be diluted, and if found too weak, it might be rendered stronger by evaporation, and thereby made to supply the want of what may be considered a more appropriate preparation.

The attention of the profession in modern times called to the value of arsenic in the treatment of hospital gangrene, by Mr. Blackadder.

"Having accordingly resolved upon making trial of this solution, I selected two severe cases in the inflammatory stage of the disease. One of them had originally received a superficial gunshot wound on the inner side of the knee joint; but at this period the sore was upwards of three inches in diameter, highly inflamed, the whole knee being swelled, and the pain excruciating, so as to make the patient cry out incessantly. The other had been wounded through the leg and thigh, but in every other respect the state of his sores was similar to that of the former.

"Diluting the arsenical solution with an equal part of water, I commenced its use by applying it to the whole surface of the sores, by means of pieces of fine lint, having previously carefully removed the glutinous discharge. Each of the patients were then provided with a small gallipot, containing a quantity of the diluted solution, and pieces of fine lint cut into the shape, but a little larger than the sores; and they were ordered to keep their sores constantly moist with the solution, and to renew the lint at least once every two hours. As this application occasioned a considerable degree of smarting when first applied, they were each provided with an opiate pill, but accompanied with a strong recommendation not to use it, if it could possibly be avoided, and by way of encouragement they were promised a certain and speedy cure. On visiting my patients next morning, it was impossible not to be struck with the change in the expression of their countenances — from that of acute pain, mingled with despair, to that of ease and gratulation. Upon inquiring whether their instructions had been strictly adhered to, I was answered, 'Yes, thank God, we feel now as if in a better world;' and, upon examining their sores, I found them completely dried up, and covered with a dark, semi-transparent, and insensible slough, of a somewhat horny consistence. The smarting, which was occasioned by the solution when first applied, had ceased, without their

having had recourse to the opiate pills; and the pain, with which they have been more or less tormented from the commencement of the disease, had also been removed soon after the application of the solution. . . . .

"The farther progress of the disease was evidently and completely arrested; and by suitable topical applications (to be afterwards particularized) for assisting nature in throwing off the slough, and cicatrizing the sore, they were in no great length of time completely cured, without having used any internal medicine, farther than what might be occasionally required to prevent constipation, and without any attention having been paid to the constitutional affection, which indeed disappeared of itself almost immediately after the destruction of the morbid action of the sores. . . . .

"From this period the solution of arsenic continued to be employed with uniform success. Patients whose sores had resisted, as was said, almost every other treatment, were admitted from other hospitals and cured by it; and it was also, I was informed, ultimately introduced into other hospitals, and proved equally successful."

Mr. Blackadder further states that the external application of the solution of arsenic was again resorted to with equal success, after the battle of Waterloo, in the British hospitals at Antwerp.[1] This observer held the view that the arsenical solution was more efficient than the actual cautery, and that it not only acted locally, but also constitutionally by absorption from the diseased surface.

Nitrate of red oxide of mercury, and the mineral acids, appear to have been employed by physicians as local applications to ulcers in the 16th and 17th centuries.

The nitrate of the red oxide of mercury and nitric acid were much recommended, and seem to have been frequently employed locally as escharotics in cases of gangrene and foul ulcers by surgeons in the sixteenth and seventeenth centuries.

The value of these remedies appears to have been most clearly demonstrated to the British surgeons, by Dr. Rollo, in 1797.

Dr. Rollo on the value of the acid nitrate of mercury and of the oxygenated muriatic acid in the local treatment of hospital gangrene.

This physician, strongly impressed with the belief that a morbid poison was acting upon the foul ulcers in the Royal Artillery Hospital of Woolwich, which, like the venereal poison, had the power of assimilation, and of being absorbed, thus producing general effects on the system, and a reaction on the sore, determined to adopt local means of treatment, consisting in the chemical destruction of the poison, and in exciting a new action.

"The oxygenated muriatic acid and the nitrates of silver and mer-

[1] *Observations on Phagedæna Gangrænosa*, pp. 21–25, pp. 49–58.

cury were the applications employed; and latterly, the oxygenated muriatic acid gas.

"When either of these was applied four or five times, the little ulcer soon put on the suppurating stage, and granulated. They did not give pain in any degree, and it was of short continuance. While the ulcer was directly touched with the nitrated silver, the whole sore was moistened with a dilute solution of nitrated mercury, or a mixture of oxygenated muriatic acid in distilled water; after which the whole was covered with lint that had been previously moistened with ether, or the oxygenated muriatic gas applied to the ulcer, and over the sore the dilute solution of nitrated mercury in distilled water.

"By these means, diligently persevered in, the poison and ulcer were destroyed, and the sore went on cicatrizing. The only failures were in those cases where the ulceration had so extended that the nitrated silver or oxygenated muriatic acid gas could not be completely employed. It is necessary to mention that washing the sore with warm water was always previously performed."

A careful examination of the works of Blane, Trotter, and others, will show that up to the war in Portugal and Spain in 1813, the British surgeons, as a general rule, did not use the actual cautery, as was done pretty generally by the French, but treated the disease chiefly as a constitutional affection, by blood-letting, emetics, and purgatives.

Up to 1813, the British navy and military surgeons, as a general rule, treated the disease upon the antiphlogistic plan and as a constitutional affection.

The indifferent success which attended its treatment by constitutional means and simple detergent applications, caused the surgeons of the British army to view it more as a local disease, capable of giving rise to severe constitutional symptoms — a change of opinion which was materially influenced by the knowledge that the French surgeons more generally considered, with Pouteau, that it was local in the first instance, and treated it by the actual cautery.

The introduction of the mineral acids, not as then generally used as stimulants or detersives, but as caustics, into the English army, during the campaign in Spain in 1813, under Lord Wellington, was due to Guthrie. This distinguished surgeon affirms that in his hands constitutional treatment and every kind of simple, mild, detergent application always failed, unless accompanied by absolute separation, the utmost possible extent of ventilation, and the greatest possible attention to cleanliness, and did not succeed even then without great loss of parts in many instances. This induced Guthrie, at Santander, in November and December, 1813, to try the mineral acids

The introduction of the mineral acids into the British army in 1813 due to Guthrie.

as caustics. In his hands this proceeding was always, however, accompanied by constitutional treatment, regulated by the nature of the symptoms, which at that station were never benefited by bleeding. At Bilbao, in 1813, when caustic applications were not used, or only as detersives, and blood-letting to the amount of two, three, or four pounds employed, out of nine hundred and seventy-two cases of hospital gangrene thus treated, three hundred and eighty-seven, or nearly one half, died. Notwithstanding this fearful mortality, Dr. Boggie, who was stationed at Bilbao, strongly advocated the exclusive constitutional treatment, and affirmed that the disease was arrested by blood-letting! At Santander, where Mr. Guthrie introduced the mineral acids as caustics, out of one hundred and sixty case, thirty-five, or less than one fourth, died; and at Passages, where Blackadder employed the arsenical solution, only two deaths are recorded in forty-one cases of hospital gangrene, or about one death in twenty cases.

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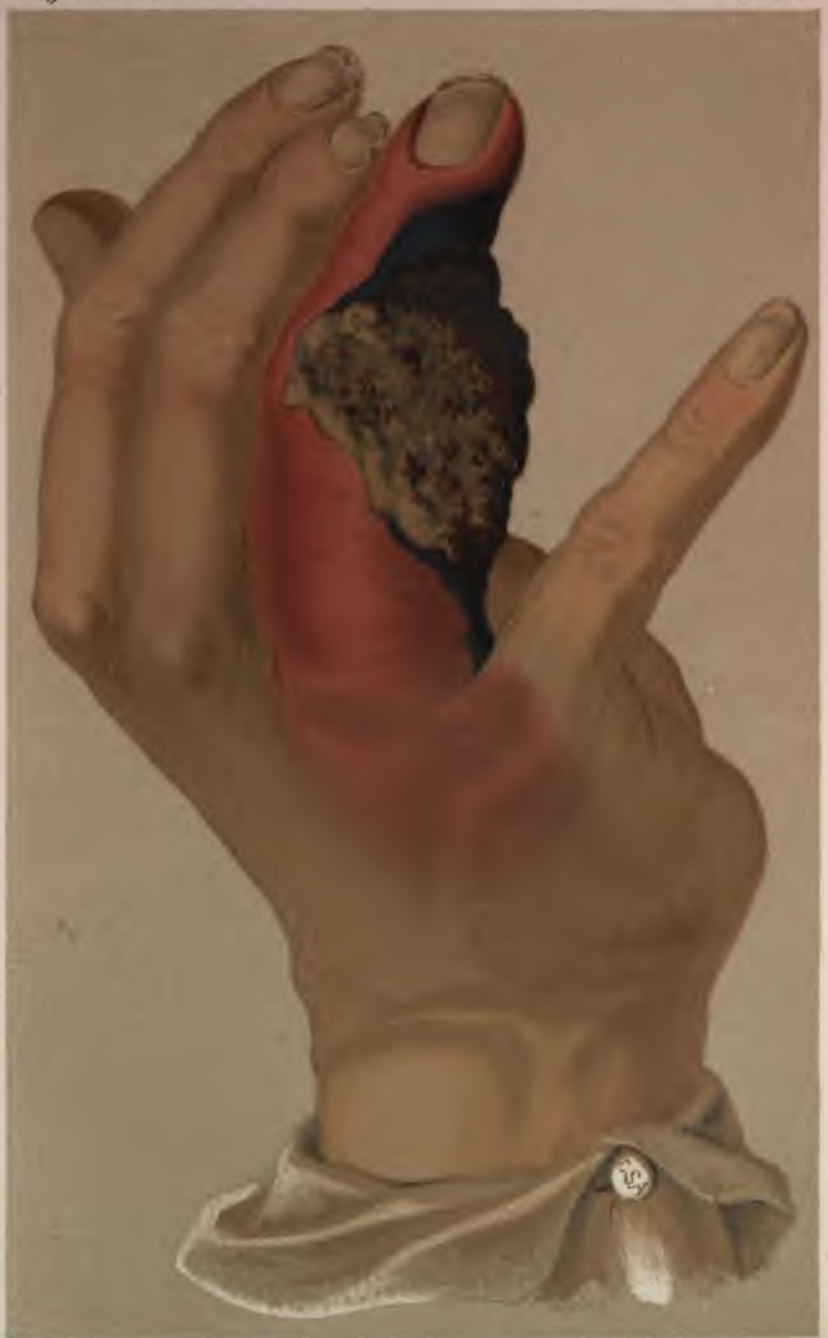

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3

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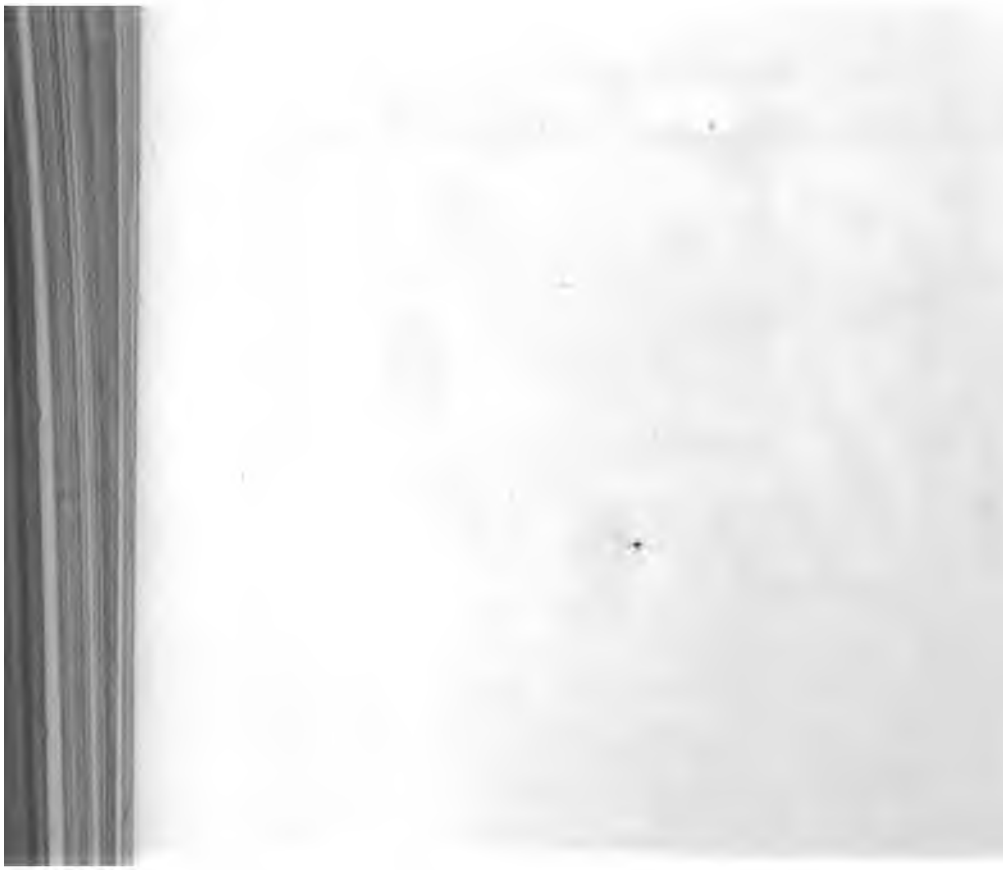

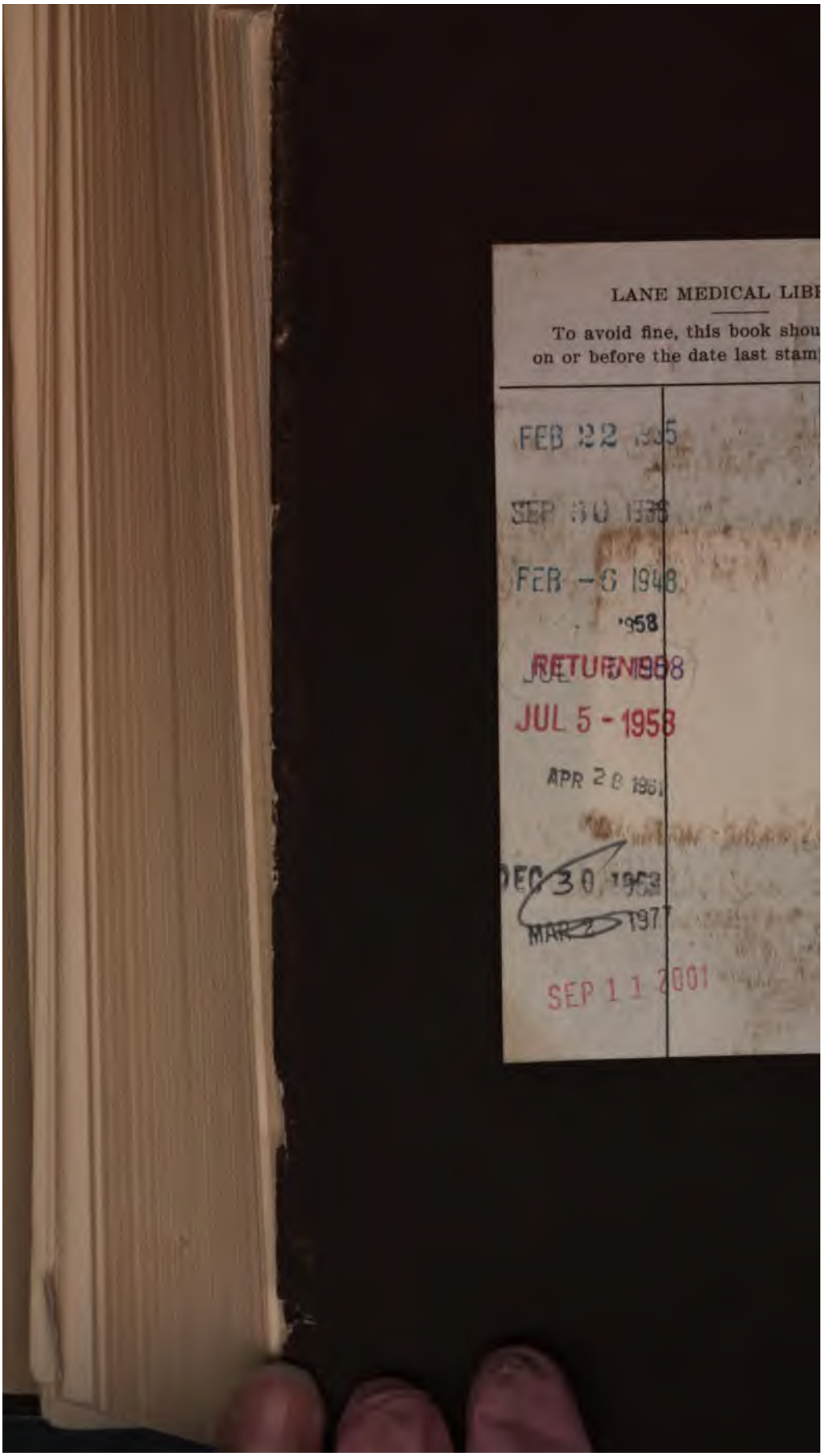
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